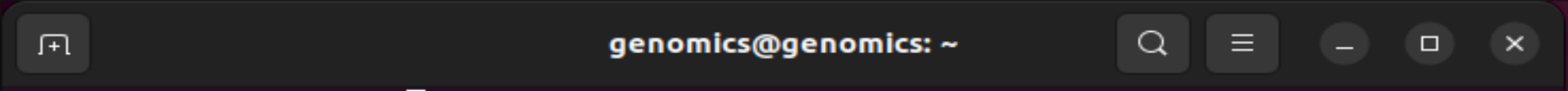


genomics@genomics:~$

Introduction to Linux

Farzaneh Salari

NGS WORKSHOP
1403/06/27

Slides based on Sophie Shaw’s Slides

Learning Objectives

1. Installing Ubuntu Virtual Machine
2. Training File and Directory Commands (Terminal)
3. Training Viewing and Searching File Commands (Terminal)
4. Installing software packages on Ubuntu OS

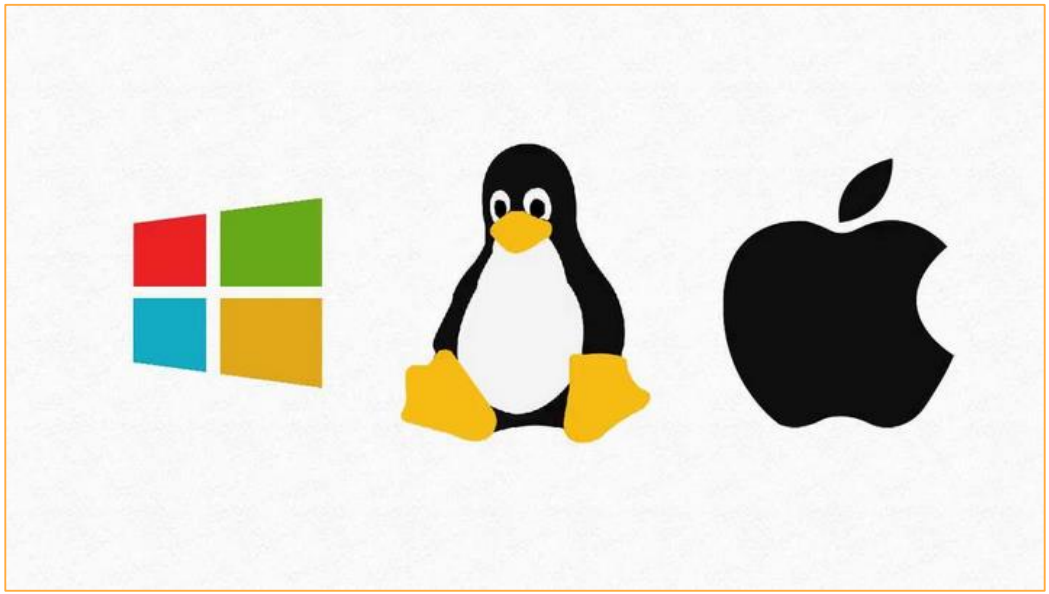
Watching vs Doing

Listen when you see this cat

Do when you see this cat

What is Linux?

- Operating System



Why Linux?

- Bioinformatics software designed to run on Linux platforms.
- Large amounts of data.
- Much faster than your Windows PC.

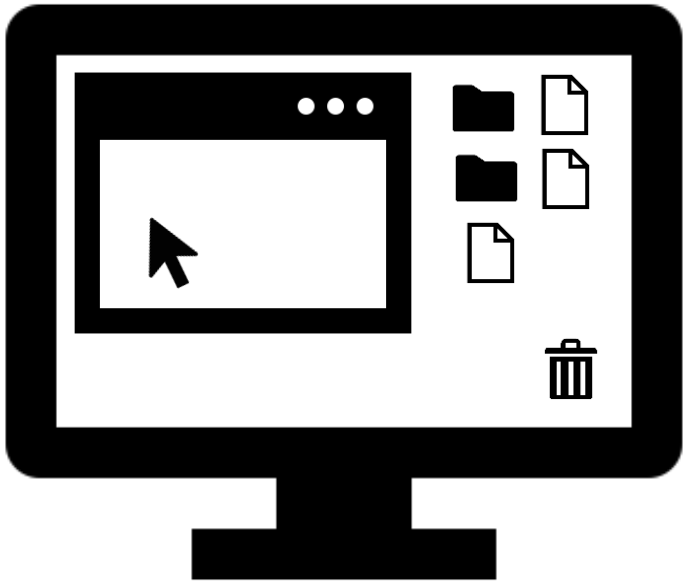
MultiQC

Trinity

gatk

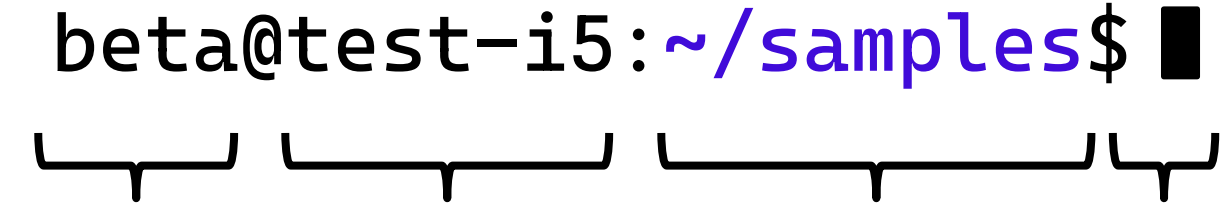
SPAdes

Command line interface



Graphical User Interface (GUI)

Command Line Interface (CLI)



Username

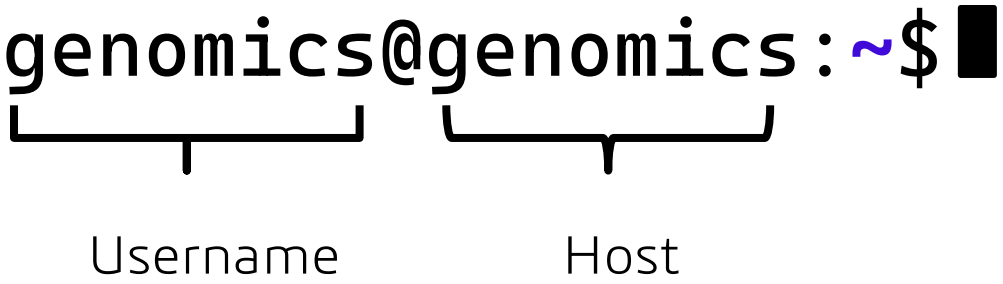
Host

Working directory

Prompt

Type your commands here!

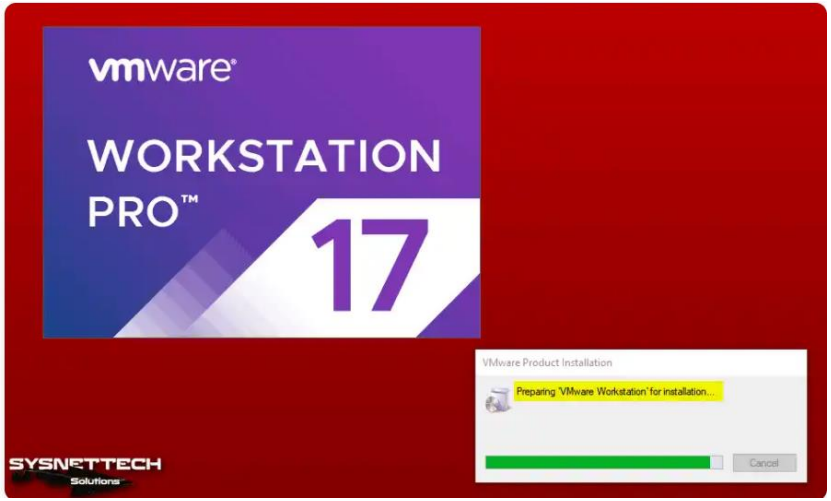
We use these names

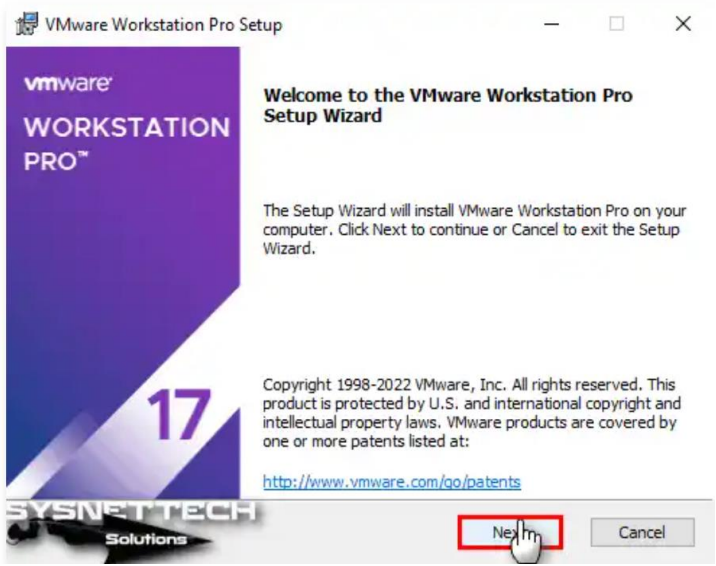


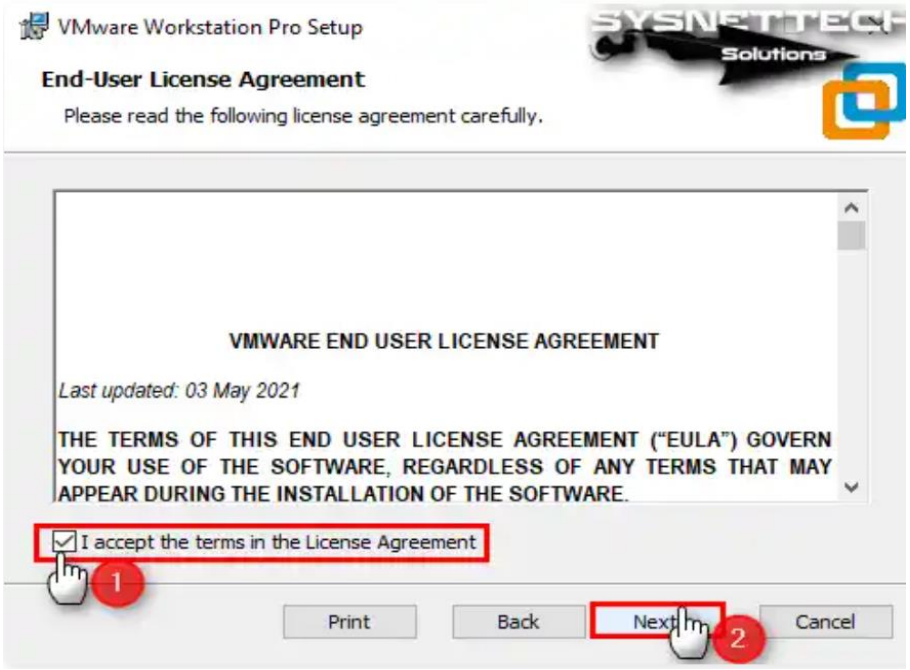
Installing Ubuntu Virtual Machine

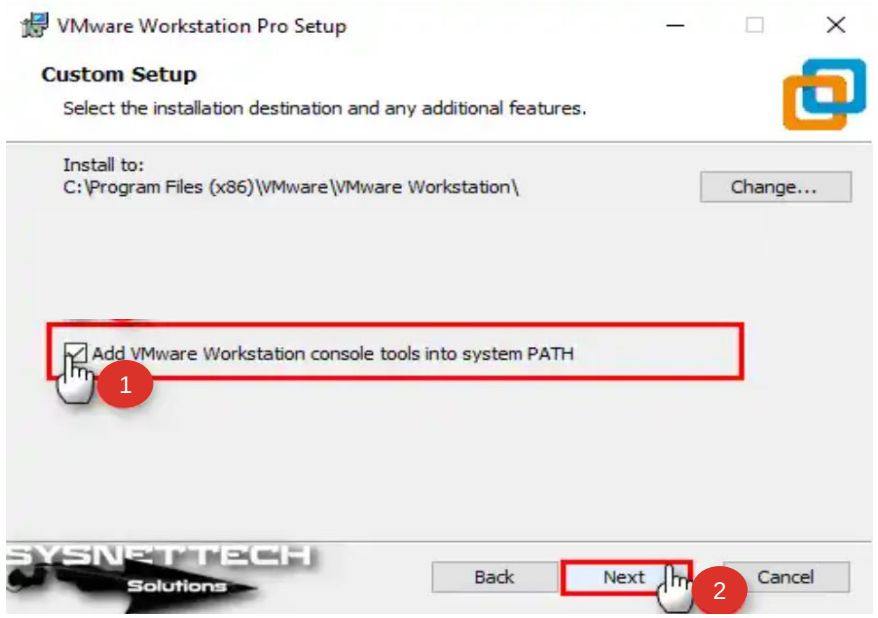
1. Downloading VMware workstation pro 17 and Ubuntu 22
    1. https://soft98.ir/os/virtual-machine/1232-vmware-workstation.html
    2. https://releases.ubuntu.com/22.04/ubuntu-22.04.5-desktop-amd64.iso
2. Installing VMware
3. Installing Ubuntu on VMware

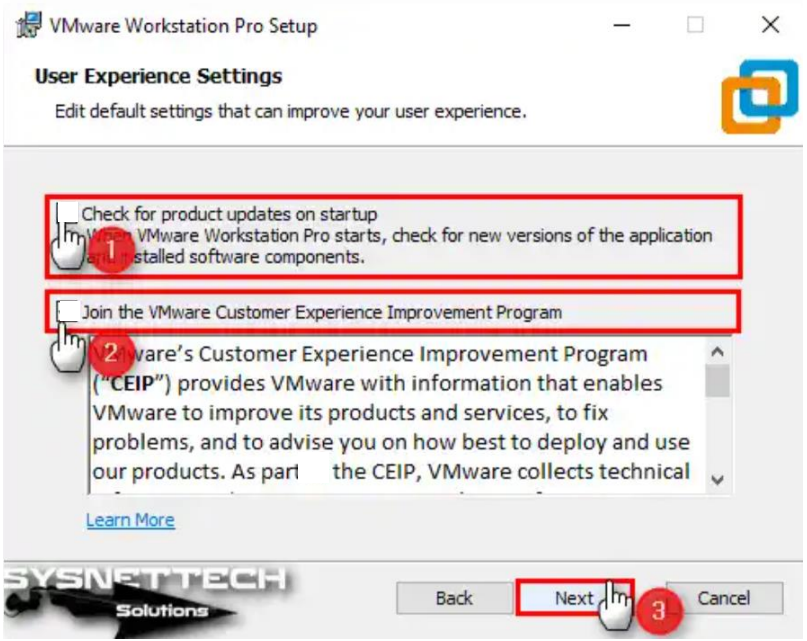
Install VMware workstation pro 17

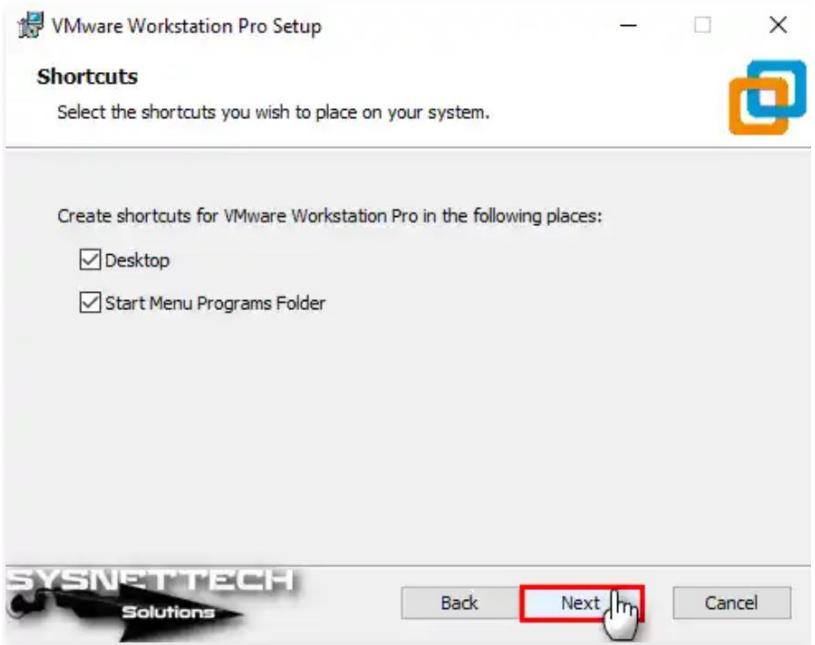

vmware
WORKSTATION
PRO™
17
VMware Product Installation
Preparing 'VMware Workstation' for installation...
Cancel
SYSNETTECH
Solutions

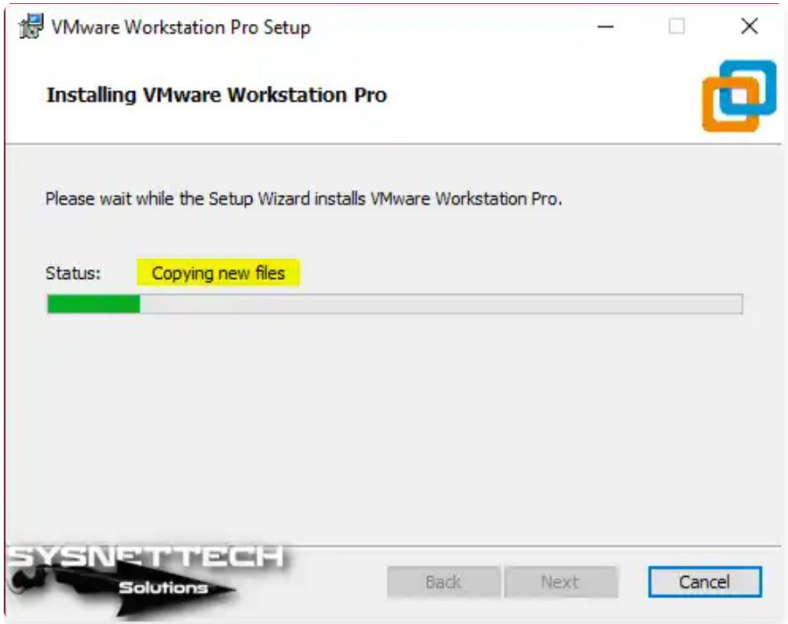

VMware Workstation Pro Setup
vmware
WORKSTATION
PRO™
17
Welcome to the VMware Workstation Pro Setup Wizard
The Setup Wizard will install VMware Workstation Pro on your computer. Click Next to continue or Cancel to exit the Setup Wizard.
Copyright 1998-2022 VMware, Inc. All rights reserved. This product is protected by U.S. and international copyright and intellectual property laws. VMware products are covered by one or more patents listed at:
http://www.vmware.com/go/patents
SYSNETTECH
Solutions
Next
Cancel

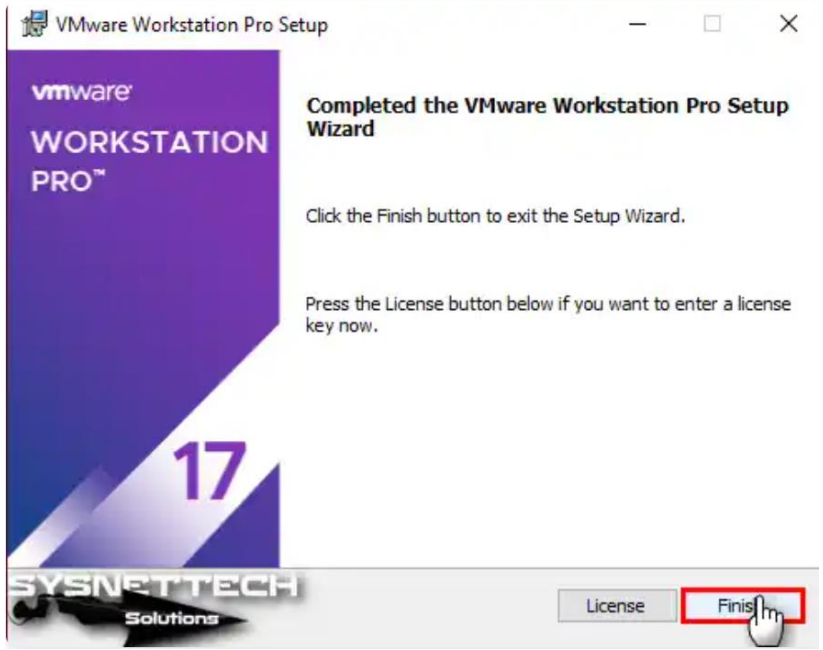

VMware Workstation Pro Setup
End-User License Agreement
Please read the following license agreement carefully.
SYSNETTECH Solutions
VMWARE END USER LICENSE AGREEMENT
Last updated: 03 May 2021
THE TERMS OF THIS END USER LICENSE AGREEMENT ("EULA") GOVERN YOUR USE OF THE SOFTWARE, REGARDLESS OF ANY TERMS THAT MAY APPEAR DURING THE INSTALLATION OF THE SOFTWARE.
I accept the terms in the License Agreement
1
Print
Back
Next
2
Cancel


VMware Workstation Pro Setup
Custom Setup
Select the installation destination and any additional features.
Install to:
C:\Program Files (x86)\VMware\VMware Workstation\
Change...
Add VMware Workstation console tools into system PATH
1
SYSNETTECH Solutions
Back
Next
2
Cancel


VMware Workstation Pro Setup
User Experience Settings
Edit default settings that can improve your user experience.
Check for product updates on startup
When VMware Workstation Pro starts, check for new versions of the application and installed software components.
Join the VMware Customer Experience Improvement Program
ware's Customer Experience Improvement Program ("CEIP") provides VMware with information that enables VMware to improve its products and services, to fix problems, and to advise you on how best to deploy and use our products. As part the CEIP, VMware collects technical
Learn More
1
2
3
Back
Next
Cancel


VMware Workstation Pro Setup
Shortcuts
Select the shortcuts you wish to place on your system.
Create shortcuts for VMware Workstation Pro in the following places:
Desktop
Start Menu Programs Folder
Back
Next
Cancel

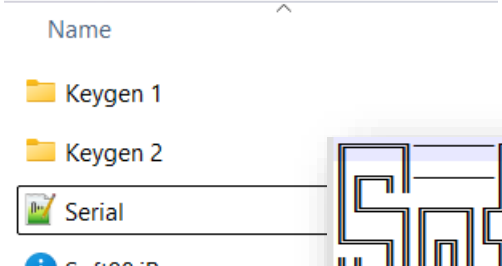

VMware Workstation Pro Setup
Installing VMware Workstation Pro
Please wait while the Setup Wizard installs VMware Workstation Pro.
Status:
Copying new files
SYSNETTECH
Solutions
Back
Next
Cancel

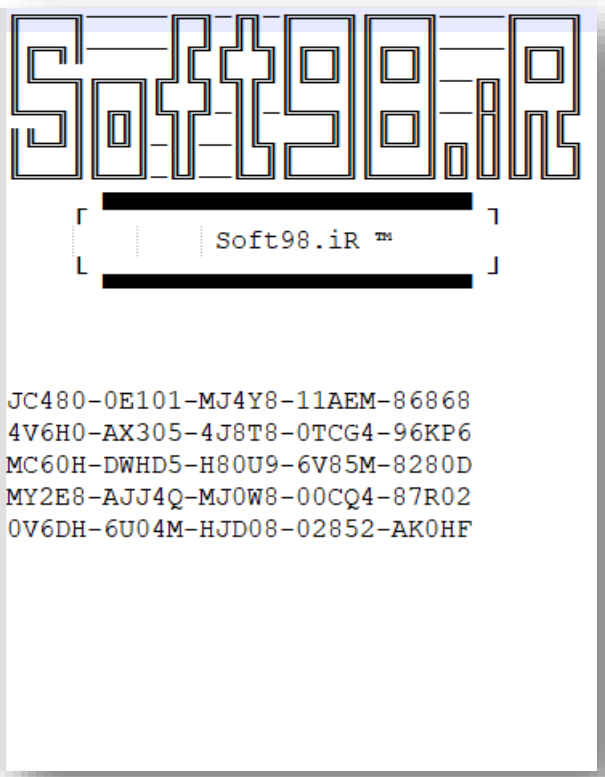

VMware Workstation Pro Setup
vmware
WORKSTATION
PRO™
17
Completed the VMware Workstation Pro Setup Wizard
Click the Finish button to exit the Setup Wizard.
Press the License button below if you want to enter a license key now.
SYSNETTECH
Solutions
License
Finish


VMware Workstation Pro Setup
You must restart your system for the configuration changes made to VMware Workstation to take effect. Click Yes to restart now or No if you plan to manually restart later.
Yes
No
SYSNETTECH
Solutions

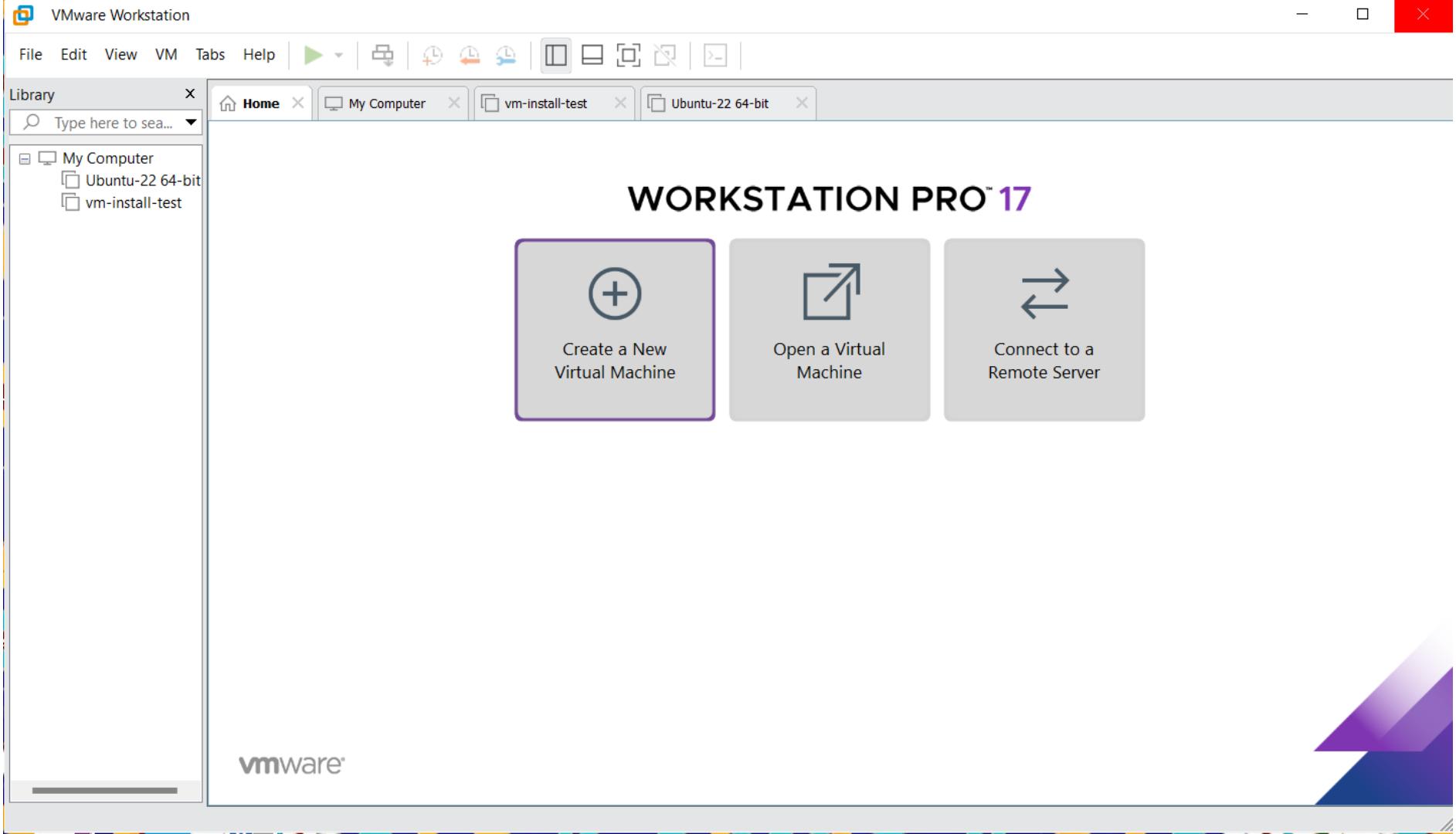
When the PC restarts,
double-click the VMware shortcut to open it.

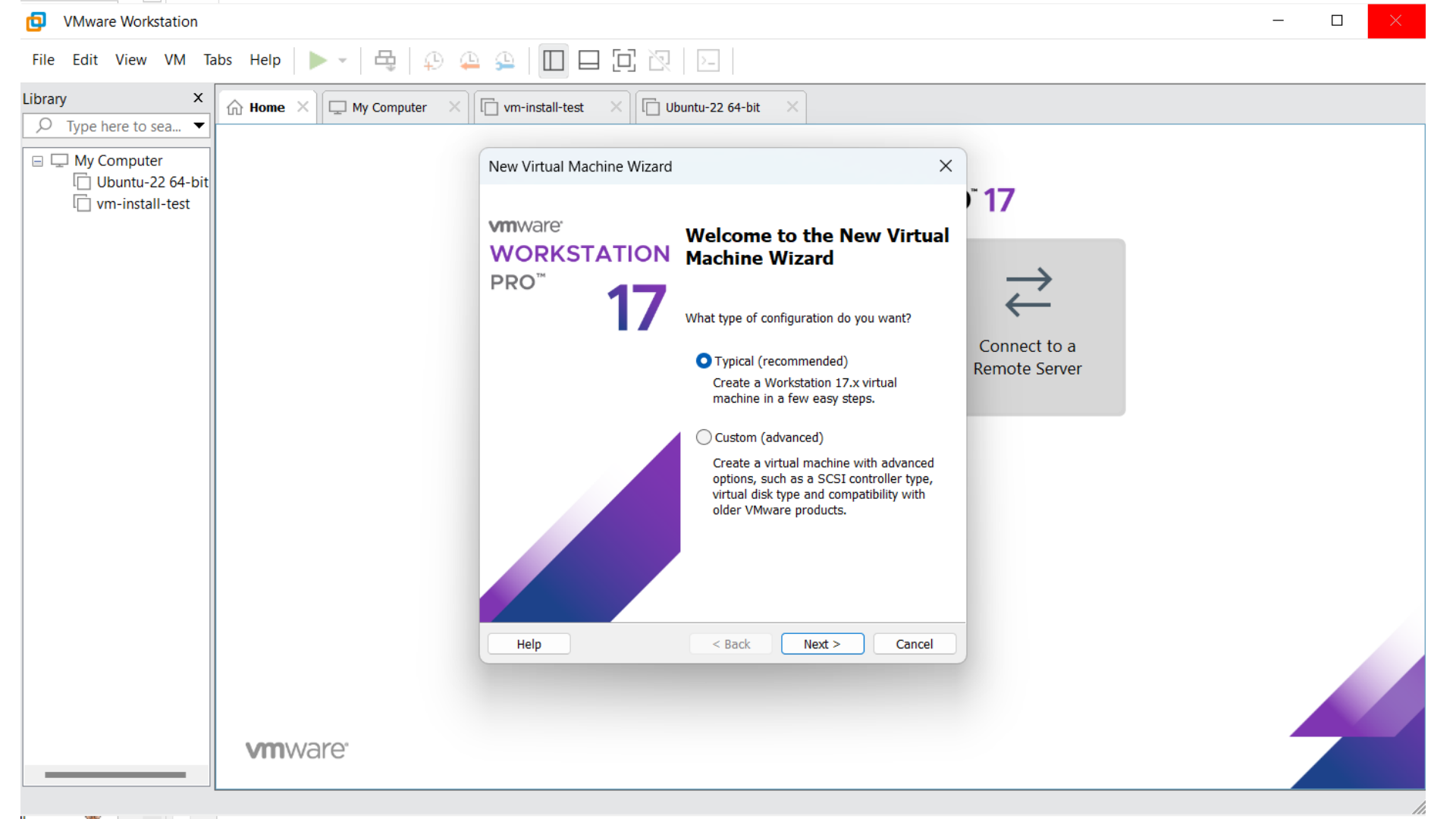
SYSNETTECH Solutions

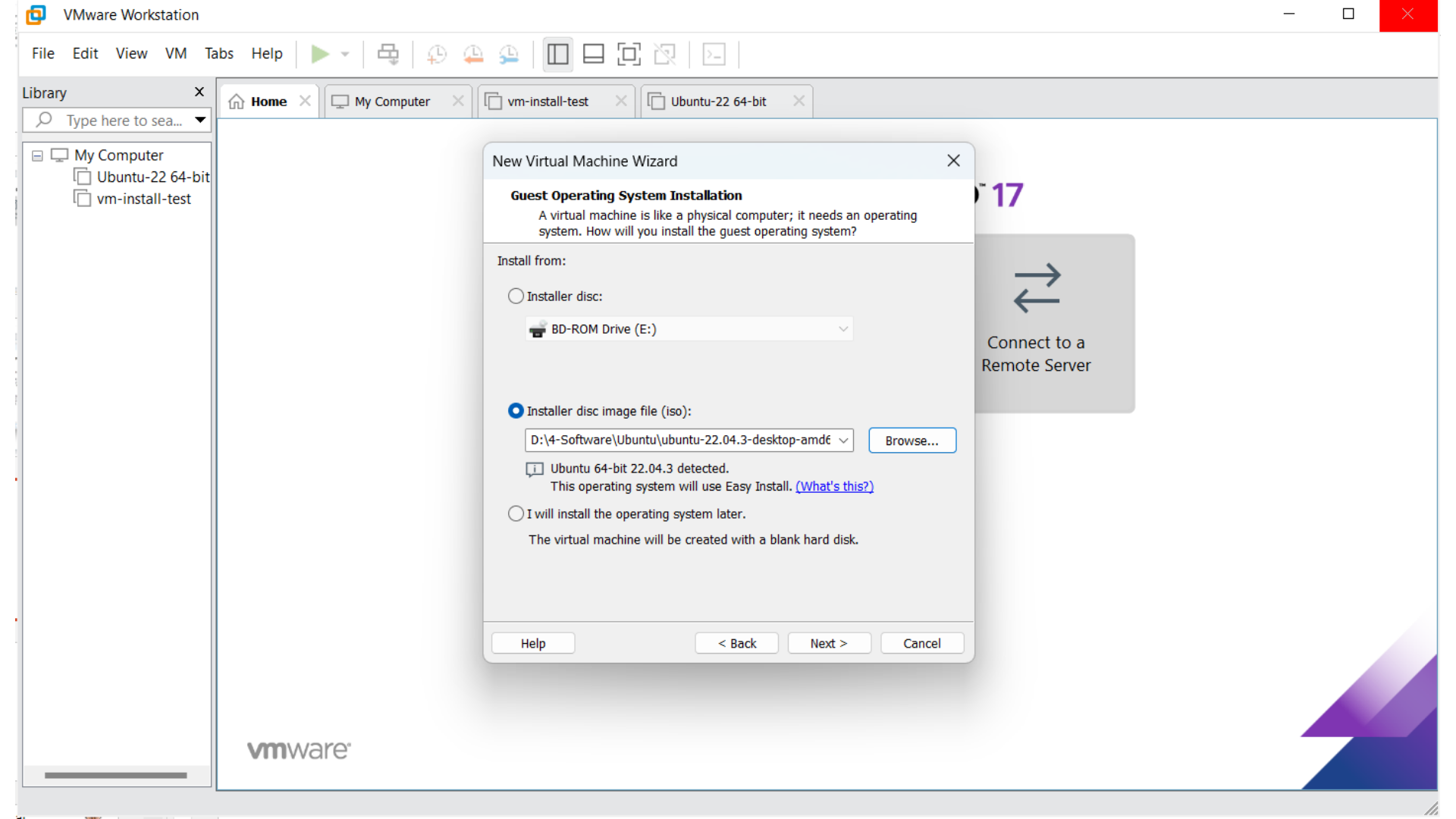


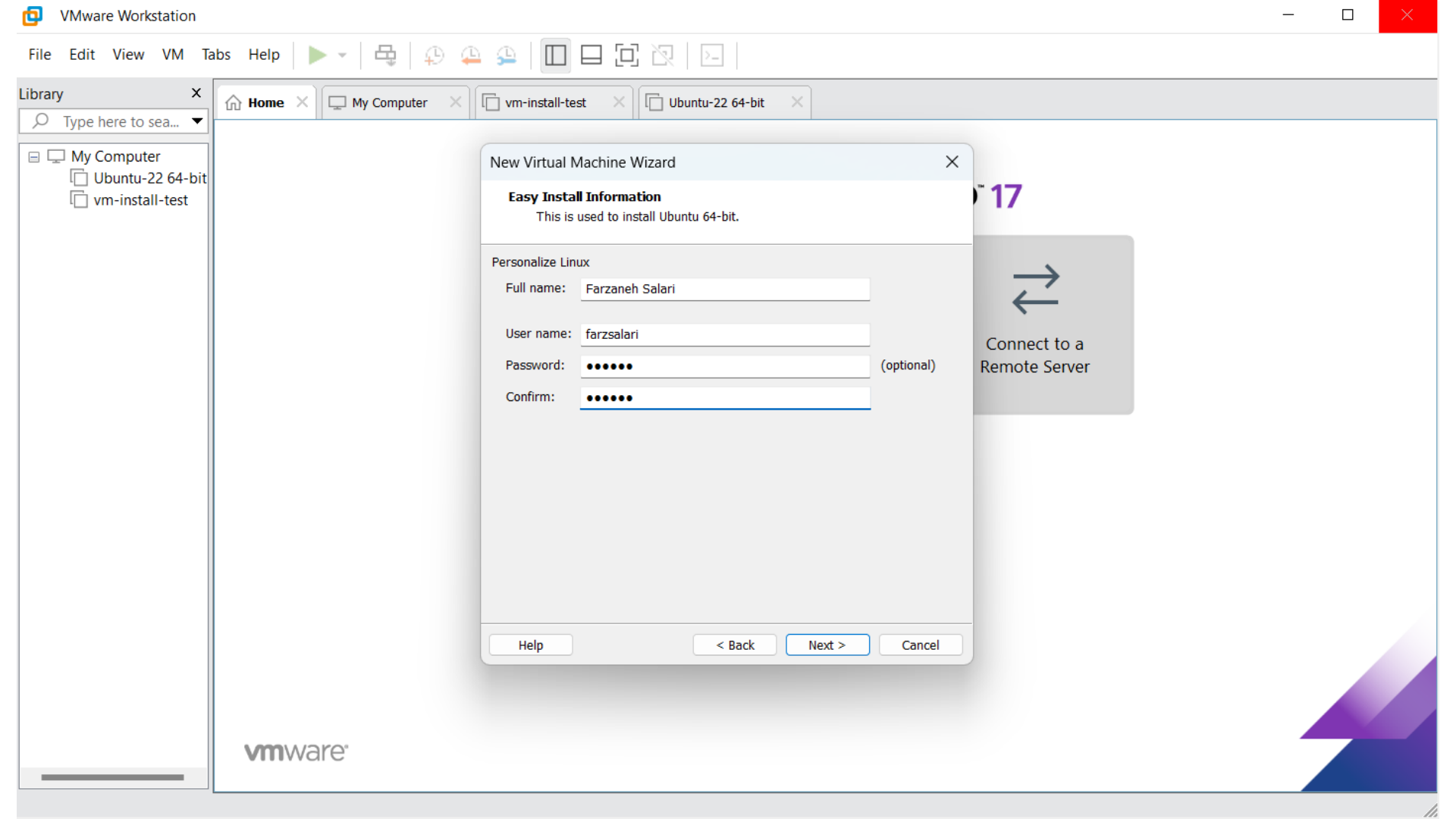


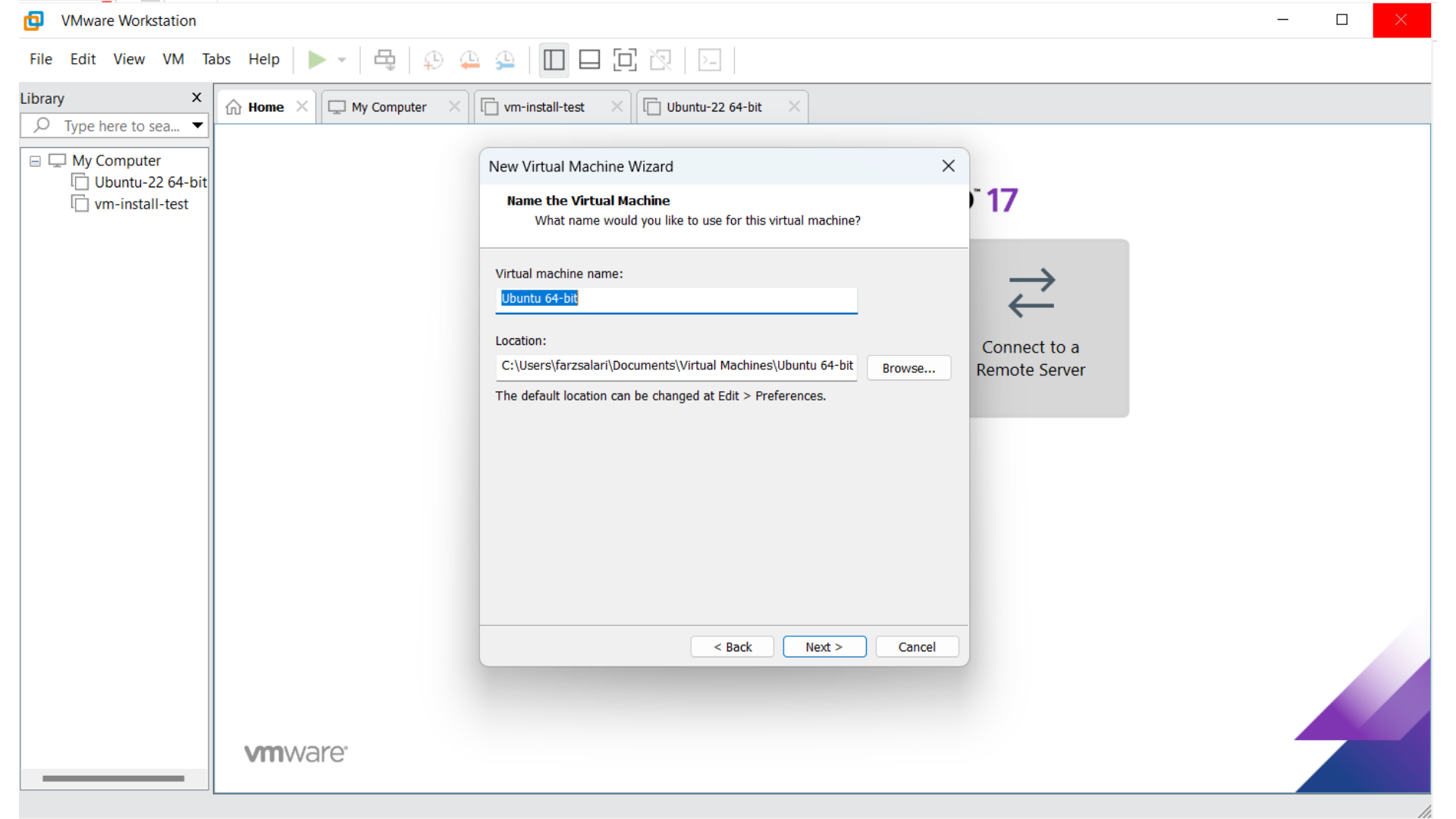
Create a New Virtual Machin

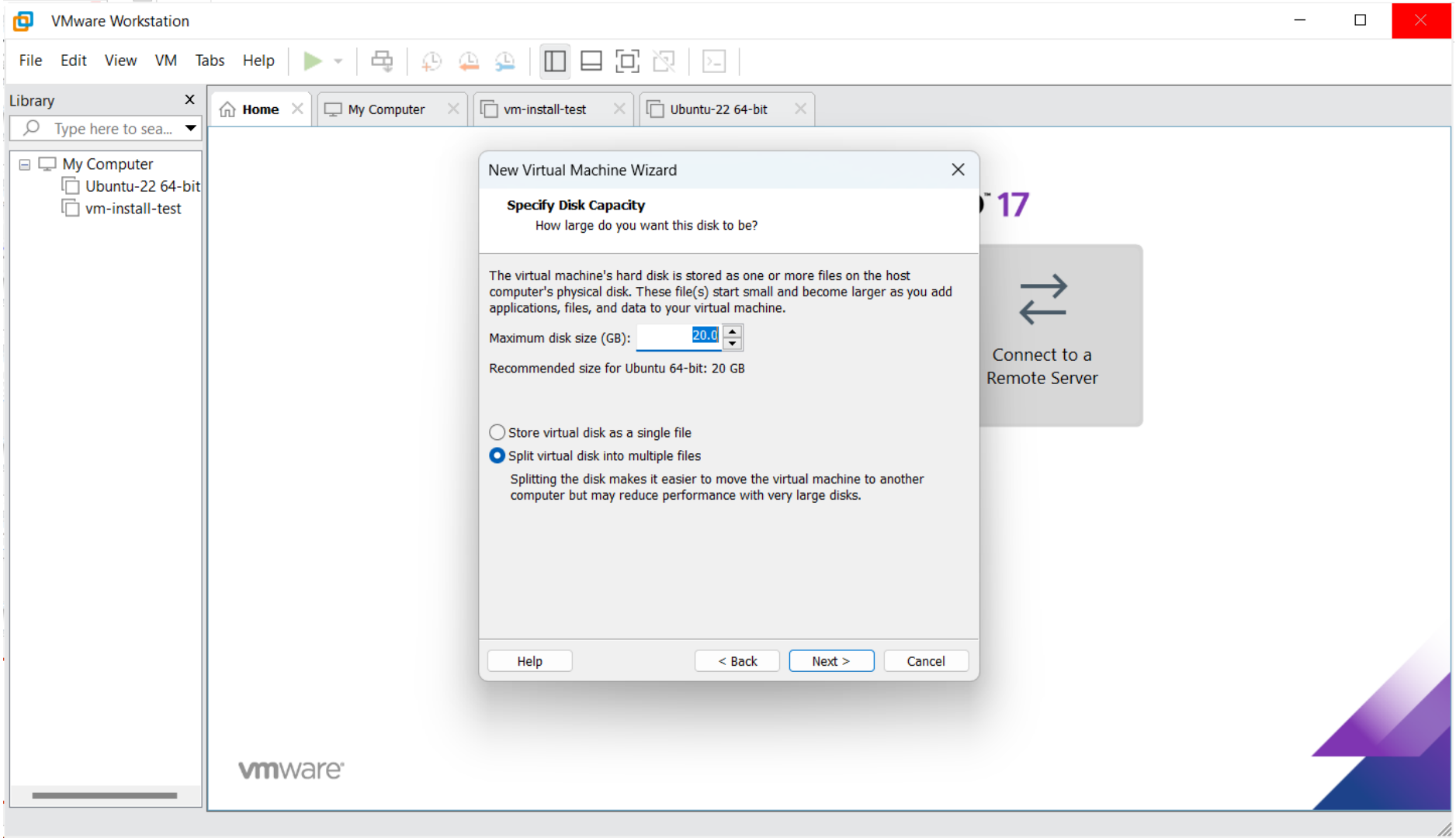

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
WORKSTATION PRO™ 17
Create a New Virtual Machine
Open a Virtual Machine
Connect to a Remote Server
vmware

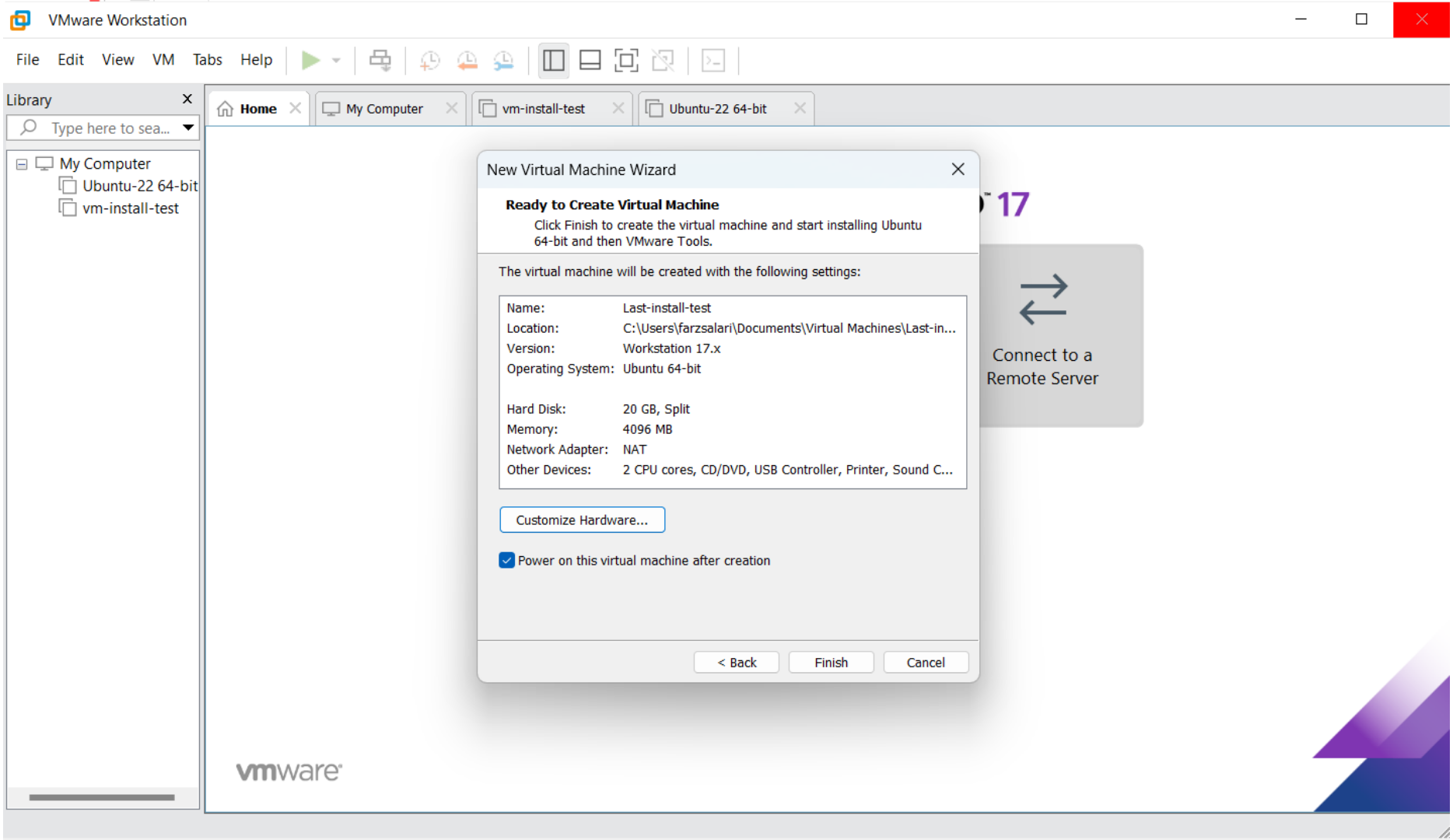

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
vmware
WORKSTATION
PRO™
17
Welcome to the New Virtual Machine Wizard
What type of configuration do you want?
Typical (recommended)
Create a Workstation 17.x virtual machine in a few easy steps.
Custom (advanced)
Create a virtual machine with advanced options, such as a SCSI controller type, virtual disk type and compatibility with older VMware products.
Help
< Back
Next >
Cancel
17
Connect to a Remote Server
vmware

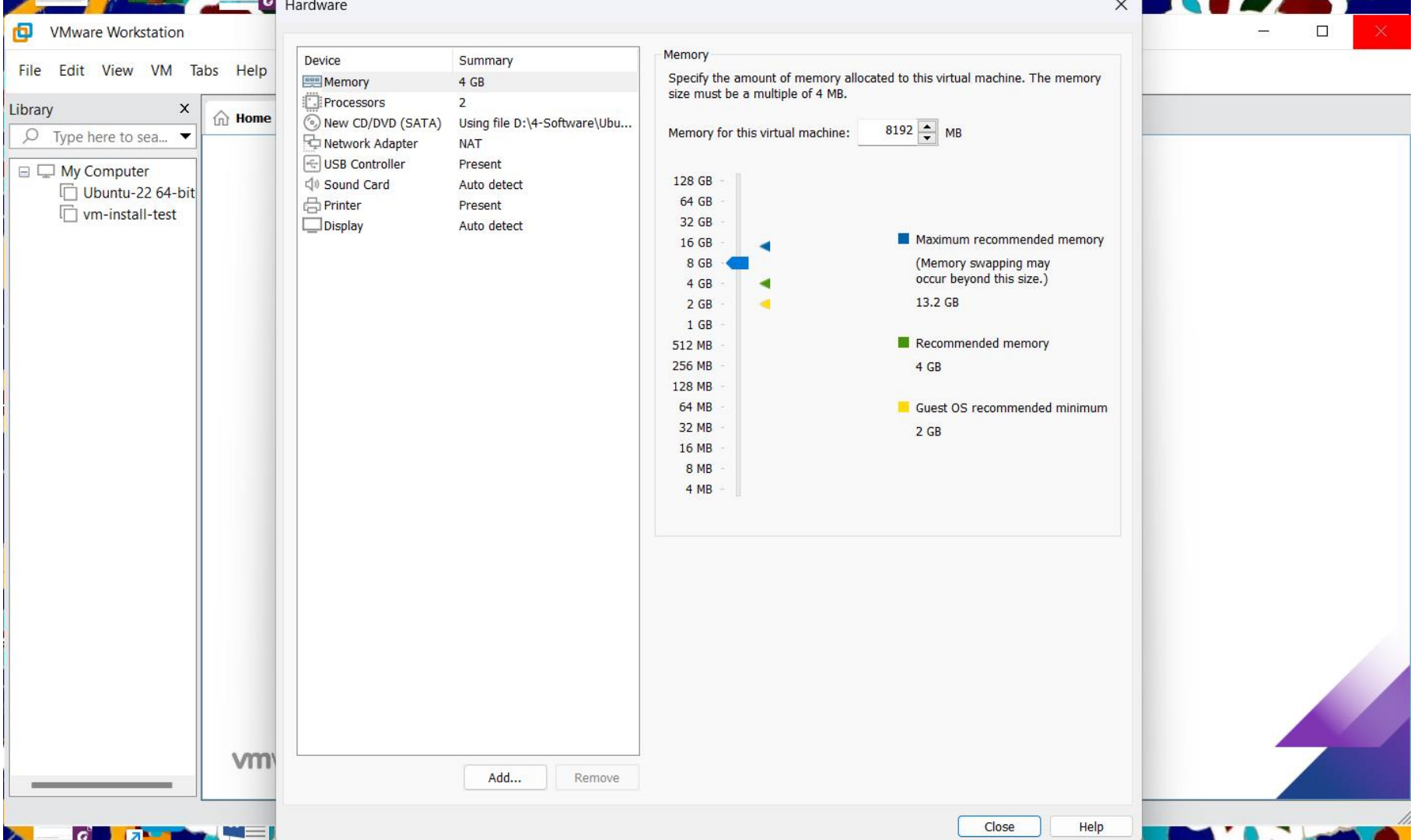

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
Guest Operating System Installation
A virtual machine is like a physical computer; it needs an operating system. How will you install the guest operating system?
Install from:
Installer disc:
BD-ROM Drive (E:)
Installer disc image file (iso):
D:\4-Software\Ubuntu\ubuntu-22.04.3-desktop-amd6
Browse...
Ubuntu 64-bit 22.04.3 detected.
This operating system will use Easy Install. (What's this?)
I will install the operating system later.
The virtual machine will be created with a blank hard disk.
Help
< Back
Next >
Cancel
17
Connect to a Remote Server
vmware


VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
Easy Install Information
This is used to install Ubuntu 64-bit.
Personalize Linux
Full name: Farzaneh Salari
User name: farzsalari
Password: ••••••
(optional)
Confirm: ••••••
Help
< Back
Next >
Cancel
17
Connect to a Remote Server
vmware

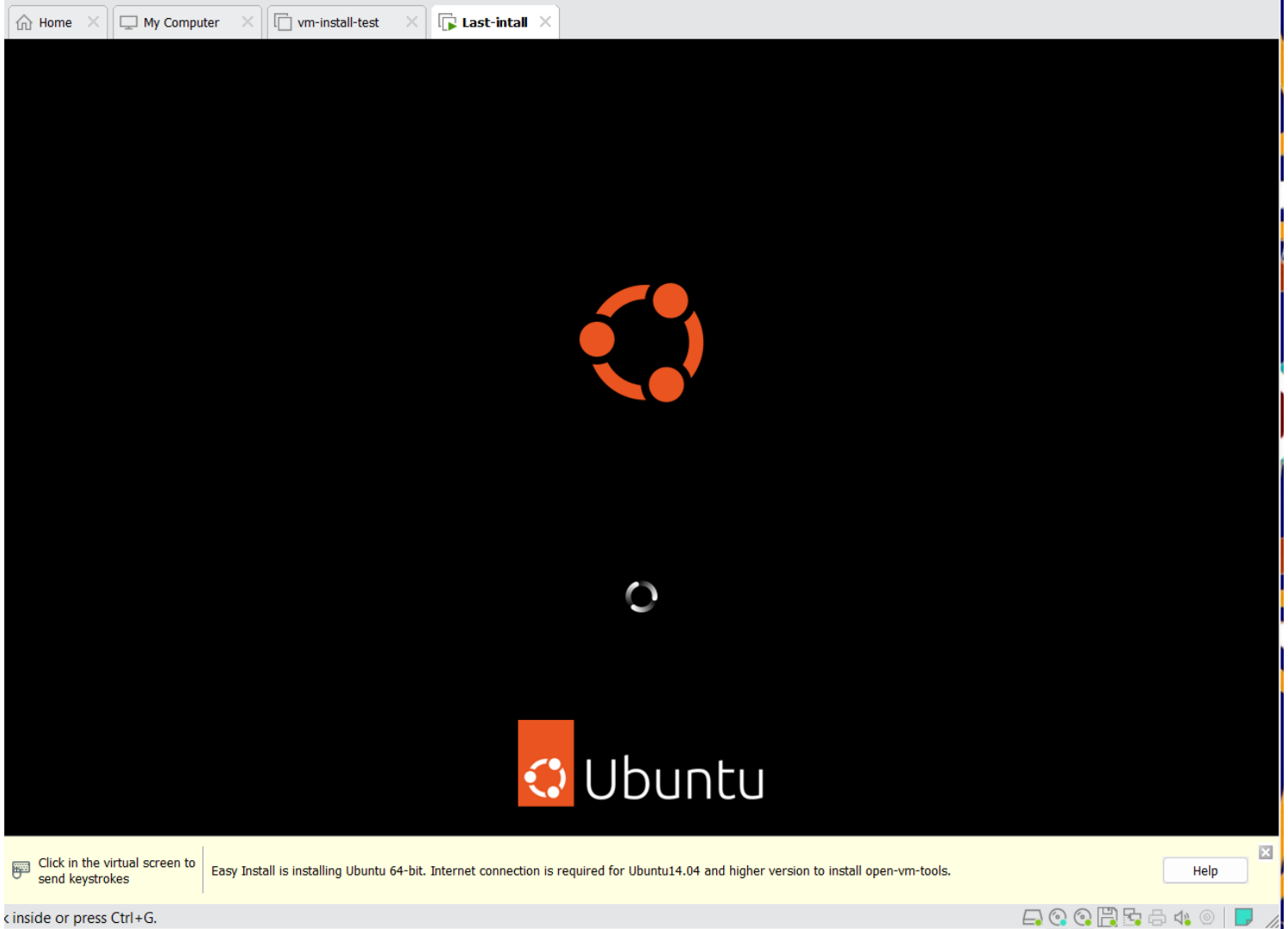

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
Name the Virtual Machine
What name would you like to use for this virtual machine?
Virtual machine name:
Ubuntu 64-bit
Location:
C:\Users\farzsalari\Documents\Virtual Machines\Ubuntu 64-bit
Browse...
The default location can be changed at Edit > Preferences.
< Back
Next >
Cancel
17
Connect to a
Remote Server
vmware

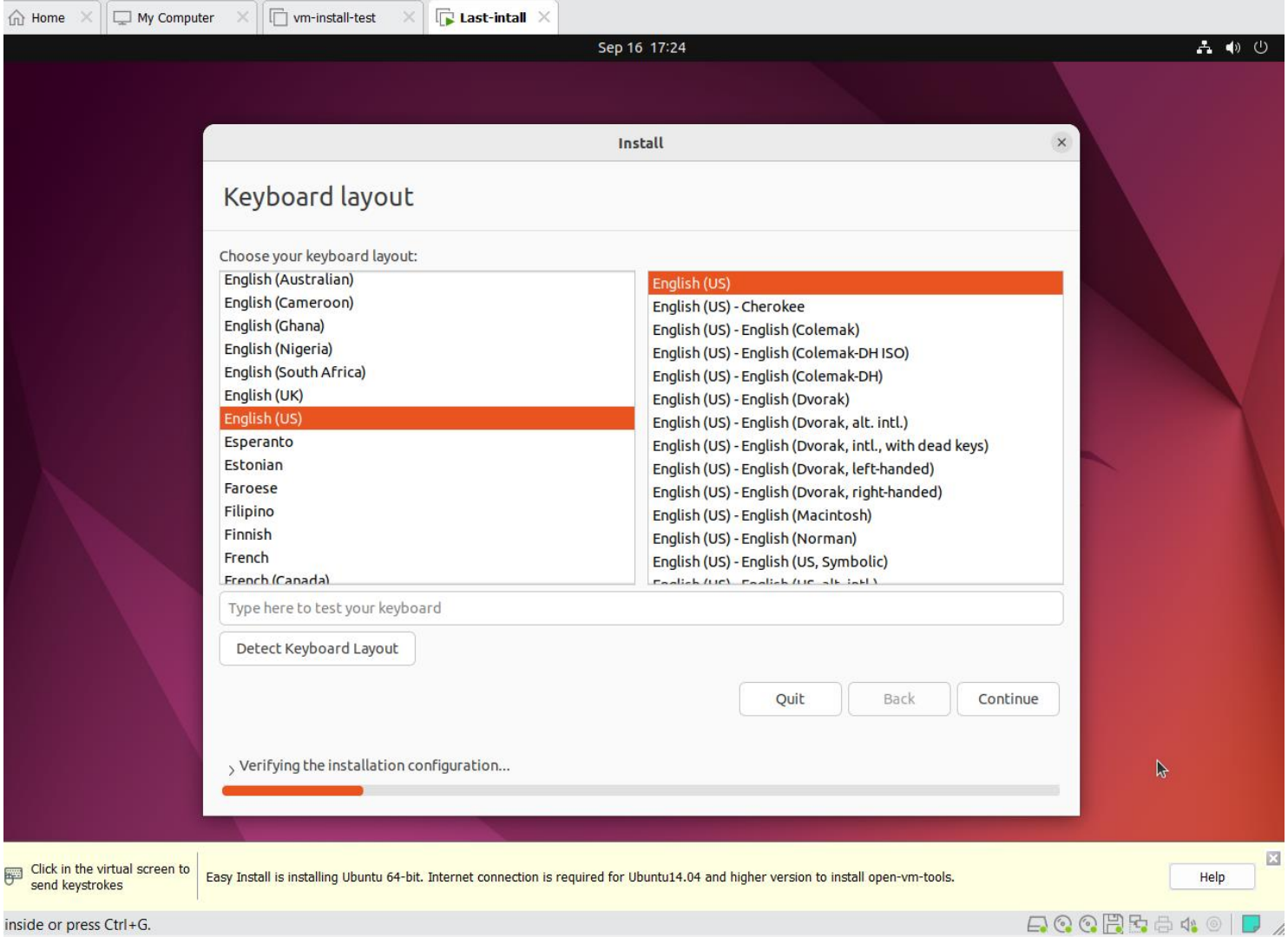

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
Specify Disk Capacity
How large do you want this disk to be?
The virtual machine's hard disk is stored as one or more files on the host computer's physical disk. These file(s) start small and become larger as you add applications, files, and data to your virtual machine.
Maximum disk size (GB): 20.0
Recommended size for Ubuntu 64-bit: 20 GB
Store virtual disk as a single file
Split virtual disk into multiple files
Splitting the disk makes it easier to move the virtual machine to another computer but may reduce performance with very large disks.
Help
< Back
Next >
Cancel
17
Connect to a Remote Server
vmware

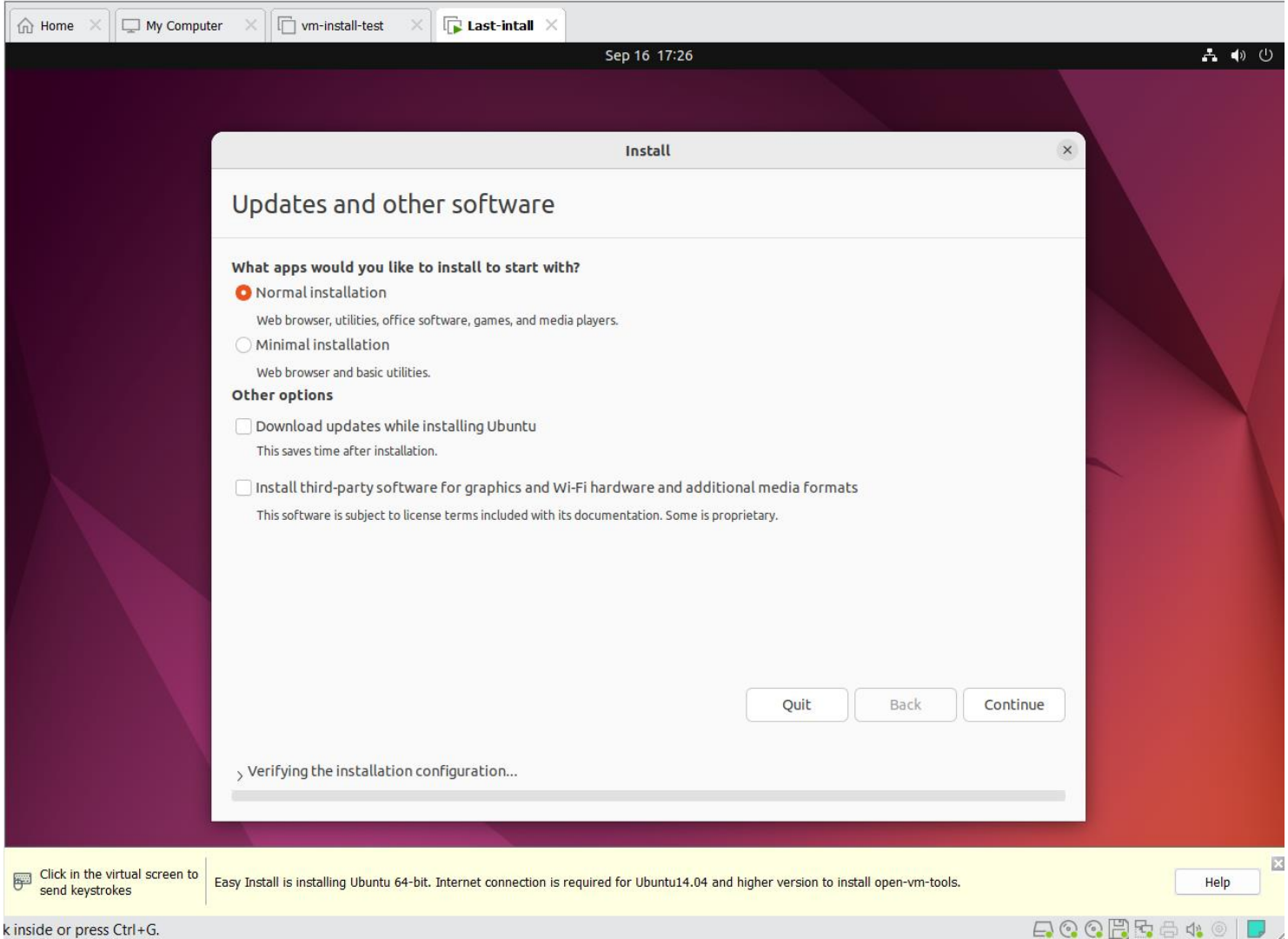

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
My Computer
vm-install-test
Ubuntu-22 64-bit
New Virtual Machine Wizard
Ready to Create Virtual Machine
Click Finish to create the virtual machine and start installing Ubuntu 64-bit and then VMware Tools.
The virtual machine will be created with the following settings:
Name: Last-install-test
Location: C:\Users\farzsalari\Documents\Virtual Machines\Last-in...
Version: Workstation 17.x
Operating System: Ubuntu 64-bit
Hard Disk: 20 GB, Split
Memory: 4096 MB
Network Adapter: NAT
Other Devices: 2 CPU cores, CD/DVD, USB Controller, Printer, Sound C...
Customize Hardware...
Power on this virtual machine after creation
< Back
Finish
Cancel
17
Connect to a Remote Server
vmware

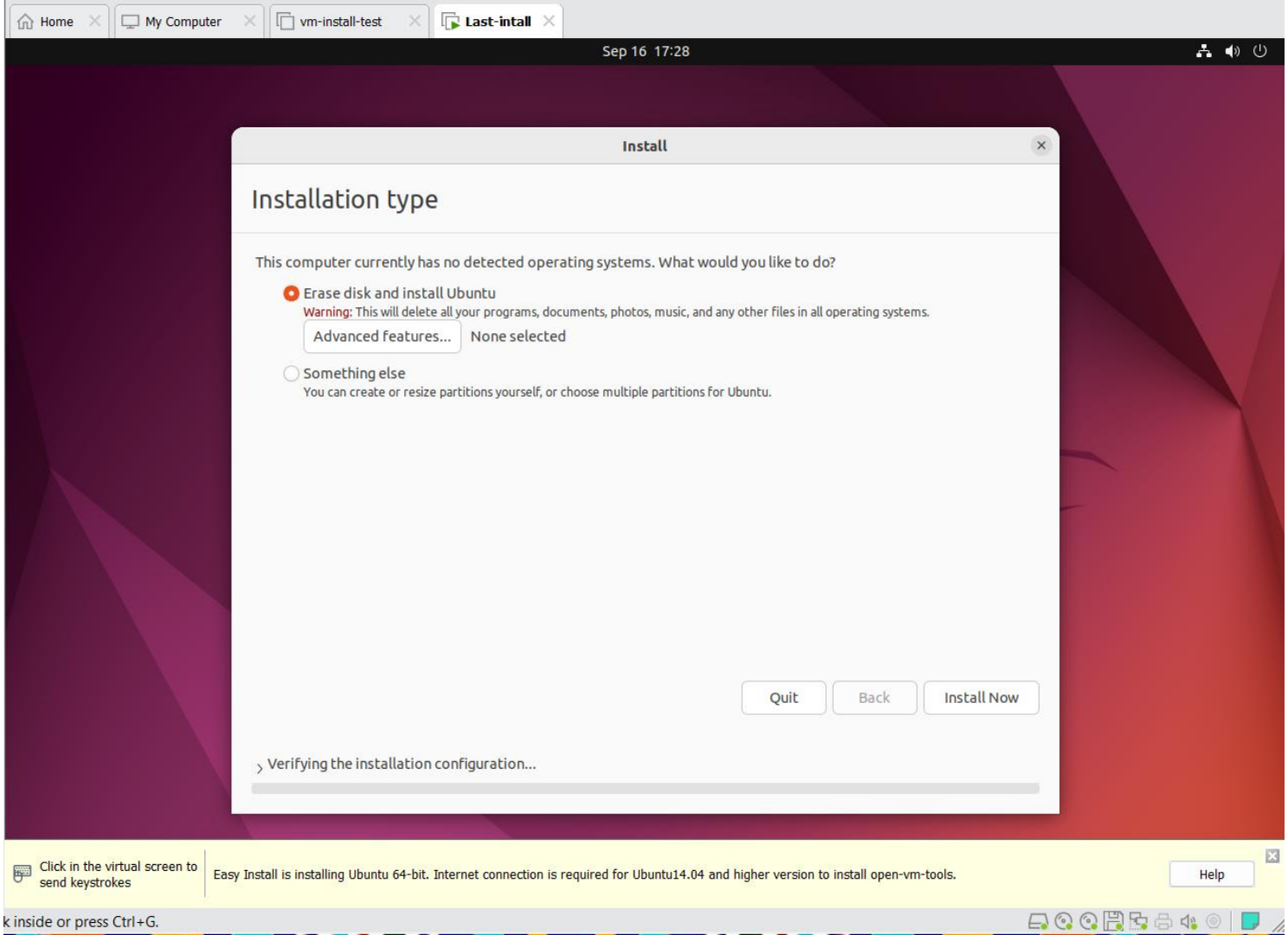

VMware Workstation
File Edit View VM Tabs Help
Library
Type here to sea...
My Computer
Ubuntu-22 64-bit
vm-install-test
Home
Hardware
Device Summary
Memory 4 GB
Processors 2
New CD/DVD (SATA) Using file D:\4-Software\Ubu...
Network Adapter NAT
USB Controller Present
Sound Card Auto detect
Printer Present
Display Auto detect
Add... Remove
Memory
Specify the amount of memory allocated to this virtual machine. The memory size must be a multiple of 4 MB.
Memory for this virtual machine: 8192 MB
128 GB
64 GB
32 GB
16 GB
8 GB
4 GB
2 GB
1 GB
512 MB
256 MB
128 MB
64 MB
32 MB
16 MB
8 MB
4 MB
Maximum recommended memory
(Memory swapping may occur beyond this size.)
13.2 GB
Recommended memory
4 GB
Guest OS recommended minimum
2 GB
Close
Help

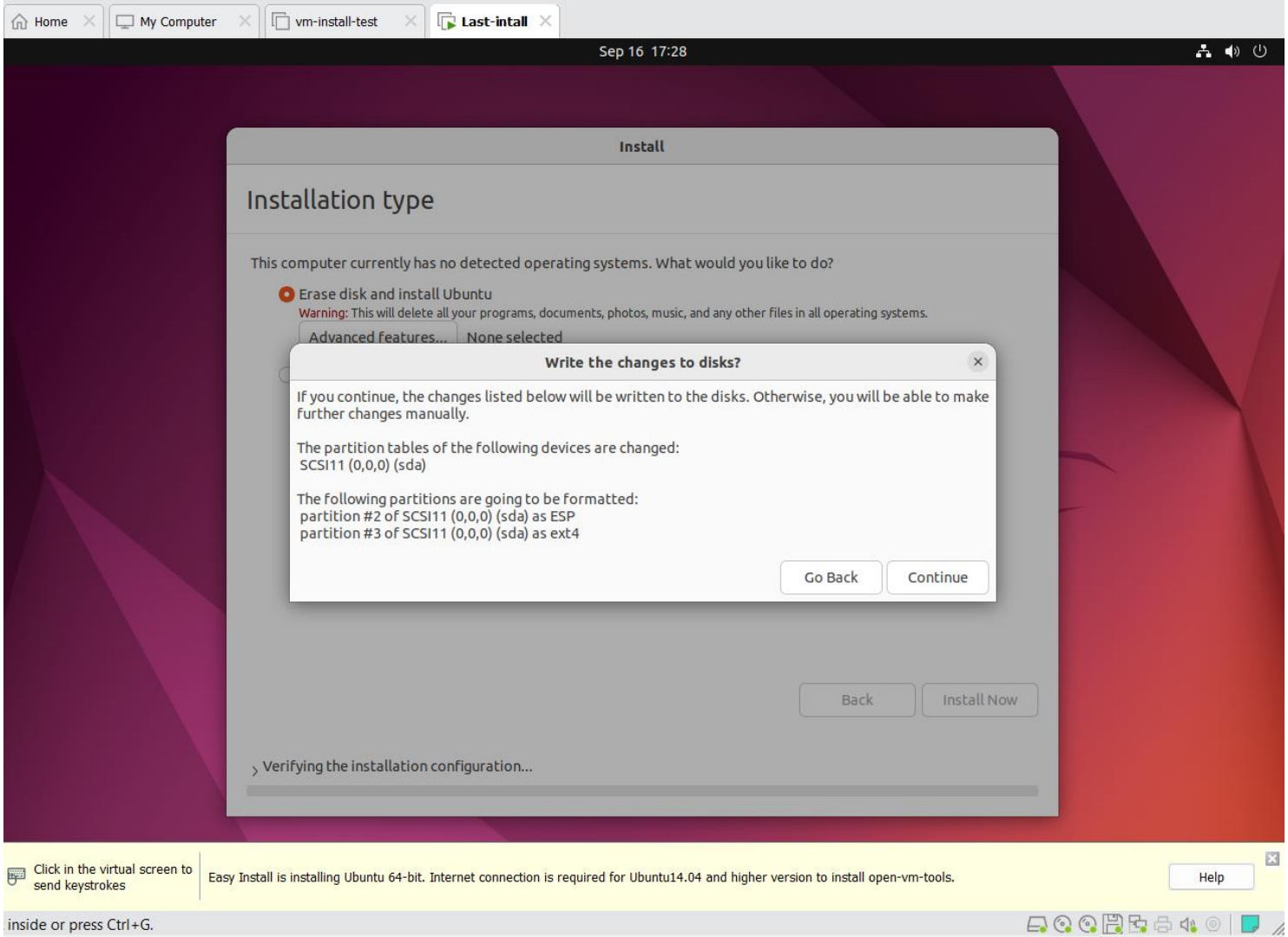
Install Ubuntu 22


Home
My Computer
vm-install-test
Last-intall
Ubuntu
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
Help
inside or press Ctrl+G.


Home
My Computer
vm-install-test
Last-intall
Sep 16 17:24
Install
Keyboard layout
Choose your keyboard layout:
English (Australian)
English (Cameroon)
English (Ghana)
English (Nigeria)
English (South Africa)
English (UK)
English (US)
Esperanto
Estonian
Faroese
Filipino
Finnish
French
French (Canada)
English (US)
English (US) - Cherokee
English (US) - English (Colemak)
English (US) - English (Colemak-DH ISO)
English (US) - English (Colemak-DH)
English (US) - English (Dvorak)
English (US) - English (Dvorak, alt. intl.)
English (US) - English (Dvorak, intl., with dead keys)
English (US) - English (Dvorak, left-handed)
English (US) - English (Dvorak, right-handed)
English (US) - English (Macintosh)
English (US) - English (Norman)
English (US) - English (US, Symbolic)
Type here to test your keyboard
Detect Keyboard Layout
Quit
Back
Continue
Verifying the installation configuration...
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
Help
inside or press Ctrl+G.


Home
My Computer
vm-install-test
Last-intall
Sep 16 17:26
Install
Updates and other software
What apps would you like to install to start with?
Normal installation
Web browser, utilities, office software, games, and media players.
Minimal installation
Web browser and basic utilities.
Other options
Download updates while installing Ubuntu
This saves time after installation.
Install third-party software for graphics and Wi-Fi hardware and additional media formats
This software is subject to license terms included with its documentation. Some is proprietary.
Quit
Back
Continue
Verifying the installation configuration...
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
Help
k inside or press Ctrl+G.


Home
My Computer
vm-install-test
Last-intall
Sep 16 17:28
Install
Installation type
This computer currently has no detected operating systems. What would you like to do?
Erase disk and install Ubuntu
Warning: This will delete all your programs, documents, photos, music, and any other files in all operating systems.
Advanced features...
None selected
Something else
You can create or resize partitions yourself, or choose multiple partitions for Ubuntu.
Quit
Back
Install Now
Verifying the installation configuration...
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
Help
k inside or press Ctrl+G.


Home
My Computer
vm-install-test
Last-intall
Sep 16 17:28
Install
Installation type
This computer currently has no detected operating systems. What would you like to do?
Erase disk and install Ubuntu
Warning: This will delete all your programs, documents, photos, music, and any other files in all operating systems.
Advanced features...
None selected
Write the changes to disks?
If you continue, the changes listed below will be written to the disks. Otherwise, you will be able to make further changes manually.
The partition tables of the following devices are changed:
SCSI11 (0,0,0) (sda)
The following partitions are going to be formatted:
partition #2 of SCSI11 (0,0,0) (sda) as ESP
partition #3 of SCSI11 (0,0,0) (sda) as ext4
Go Back
Continue
Back
Install Now
Verifying the installation configuration...
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
Help
inside or press Ctrl+G.

Home | My Computer | vm-install-test | Last-intall

Sep 16 17:30

Install

Where are you?

Tehran

Back | Continue

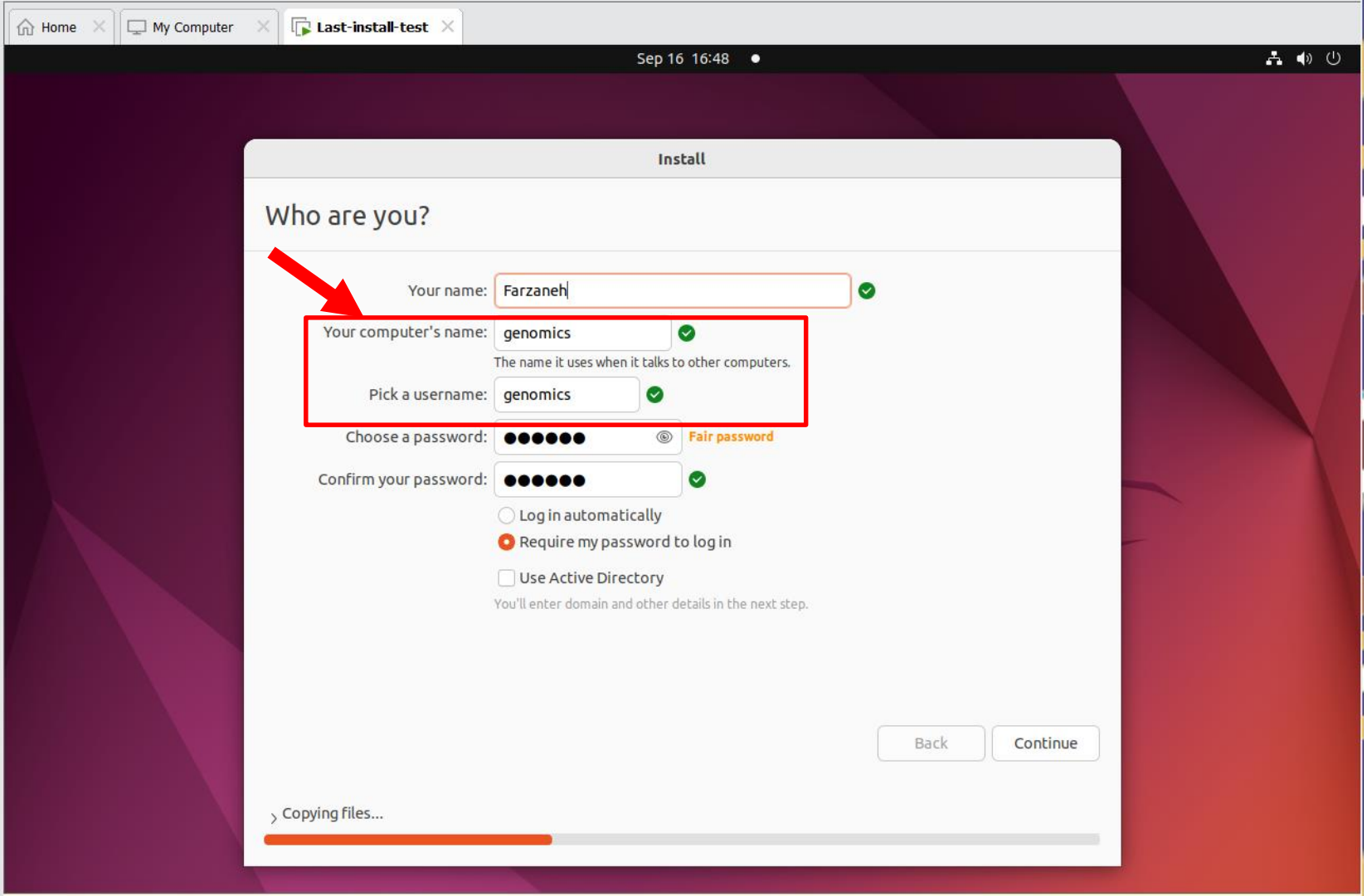
Creating ext4 file system for / in partition #3 of SCSI11 (0,0,0) (sda)...

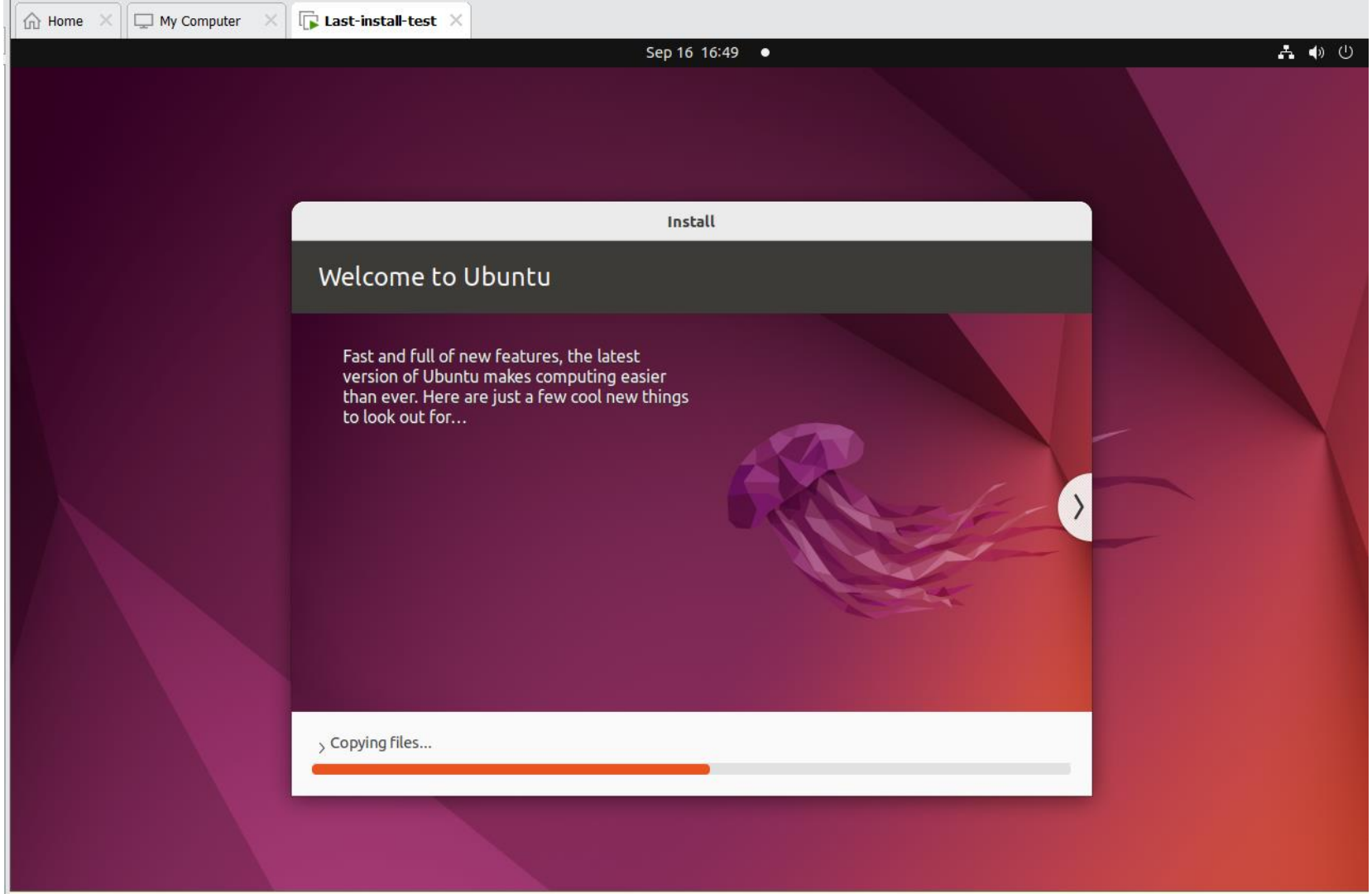
Click in the virtual screen to send keystrokes

Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.

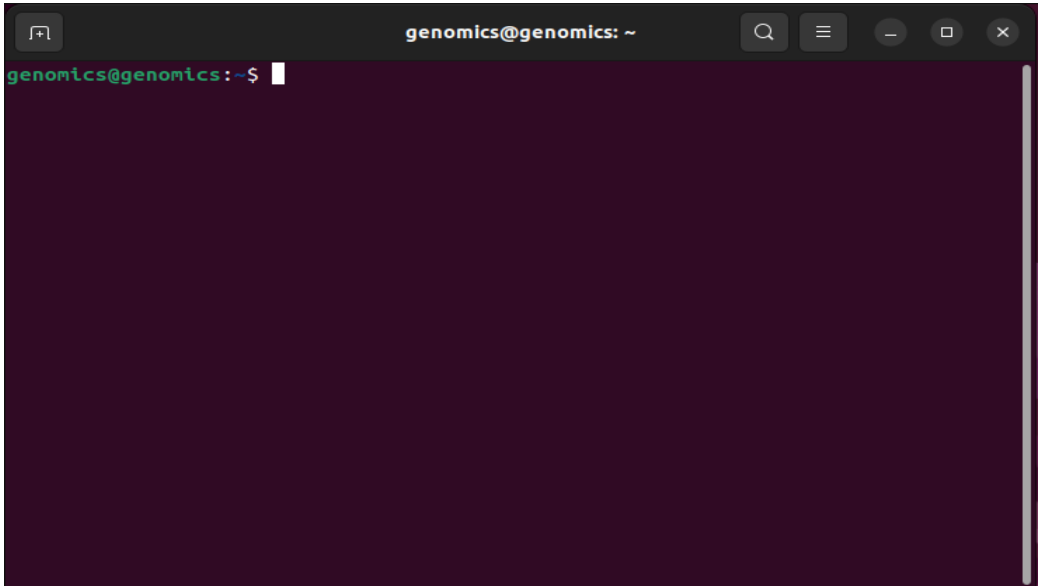
Help

inside or press Ctrl+G.


Home
My Computer
Last-install-test
Sep 16 16:48
Install
Who are you?
Your name:
Farzaneh
Your computer's name:
genomics
The name it uses when it talks to other computers.
Pick a username:
genomics
Choose a password:
Fair password
Confirm your password:
Log in automatically
Require my password to log in
Use Active Directory
You'll enter domain and other details in the next step.
Back
Continue
Copying files...


Home
My Computer
Last-install-test
Sep 16 16:49
Install
Welcome to Ubuntu
Fast and full of new features, the latest version of Ubuntu makes computing easier than ever. Here are just a few cool new things to look out for…
Copying files...

The Terminal



The Command Line, The Shell, The Prompt

Where you see this “$” followed by text, I want you to type the text on your command line

Unix/Linux Command Reference

FOSSwire.com

File Commands

ls – directory listing
ls -al – formatted listing with hidden files
cd *dir* - change directory to *dir*
cd – change to home
pwd – show current directory
mkdir *dir* – create a directory *dir*
rm *file* – delete *file*
rm -r *dir* – delete directory *dir*
rm -f *file* – force remove *file*
rm -rf *dir* – force remove directory *dir* *
cp *file1 file2* – copy *file1* to *file2*
cp -r *dir1 dir2* – copy *dir1* to *dir2*; create *dir2* if it doesn't exist
mv *file1 file2* – rename or move *file1* to *file2*
if *file2* is an existing directory, moves *file1* into directory *file2*
ln -s *file link* – create symbolic link *link* to *file*
touch *file* – create or update *file*
cat > *file* – places standard input into *file*
more *file* – output the contents of *file*
head *file* – output the first 10 lines of *file*
tail *file* – output the last 10 lines of *file*
tail -f *file* – output the contents of *file* as it grows, starting with the last 10 lines

Process Management

ps – display your currently active processes
top – display all running processes
kill *pid* – kill process id *pid*
killall *proc* – kill all processes named *proc* *
bg – lists stopped or background jobs; resume a stopped job in the background
fg – brings the most recent job to foreground
fg *n* – brings job *n* to the foreground

File Permissions

chmod *octal file* – change the permissions of *file* to *octal*, which can be found separately for user, group, and world by adding:

- 4 – read (r)
- 2 – write (w)
- 1 – execute (x)

Examples:
chmod 777 – read, write, execute for all
chmod 755 – rwx for owner, rx for group and world
For more options, see **man chmod**.

SSH

ssh *user@host* – connect to *host* as *user*
ssh -p *port user@host* – connect to *host* on port *port* as *user*
ssh-copy-id *user@host* – add your key to *host* for *user* to enable a keyed or passwordless login

Searching

grep *pattern files* – search for *pattern* in *files*
grep -r *pattern dir* – search recursively for *pattern* in *dir*
command **|** **grep *pattern*** – search for *pattern* in the output of *command*
locate *file* – find all instances of *file*

System Info

date – show the current date and time
cal – show this month's calendar
uptime – show current uptime
w – display who is online
whoami – who you are logged in as
finger *user* – display information about *user*
uname -a – show kernel information
cat /proc/cpuinfo – cpu information
cat /proc/meminfo – memory information
man *command* – show the manual for *command*
df – show disk usage
du – show directory space usage
free – show memory and swap usage
whereis *app* – show possible locations of *app*
which *app* – show which *app* will be run by default

Compression

tar cf *file.tar files* – create a tar named *file.tar* containing *files*
tar xf *file.tar* – extract the files from *file.tar*
tar czf *file.tar.gz files* – create a tar with Gzip compression
tar xzf *file.tar.gz* – extract a tar using Gzip
tar cjf *file.tar.bz2* – create a tar with Bzip2 compression
tar xjf *file.tar.bz2* – extract a tar using Bzip2
gzip *file* – compresses *file* and renames it to *file.gz*
gzip -d *file.gz* – decompresses *file.gz* back to *file*

Network

ping *host* – ping *host* and output results
whois *domain* – get whois information for *domain*
dig *domain* – get DNS information for *domain*
dig -x *host* – reverse lookup *host*
wget *file* – download *file*
wget -c *file* – continue a stopped download

Installation

Install from source:
./configure
make
make install
dpkg -i *pkg.deb* – install a package (Debian)
rpm -Uvh *pkg.rpm* – install a package (RPM)

Shortcuts

Ctrl+C – halts the current command
Ctrl+Z – stops the current command, resume with **fg** in the foreground or **bg** in the background
Ctrl+D – log out of current session, similar to **exit**
Ctrl+W – erases one word in the current line
Ctrl+U – erases the whole line
Ctrl+R – type to bring up a recent command
!! - repeats the last command
exit – log out of current session

* use with extreme caution.

Terminal Commands

- Run (VM or https://www.terminaltemple.com/)
  - Exploring your current directory
  - Making and changing directories
  - Removing files and directories
- Run (VM or https://sandbox.bio/tutorials/terminal-basics)
  - Viewing and manipulating files
  - Searching files
  - Putting it all together

Location is Important

First Task – Where am I?

```
$ pwd
```

```
genomics@genomics:~$ pwd
/home/genomics
genomics@genomics:~$
```

This is your “present working directory”.

/

= ROOT

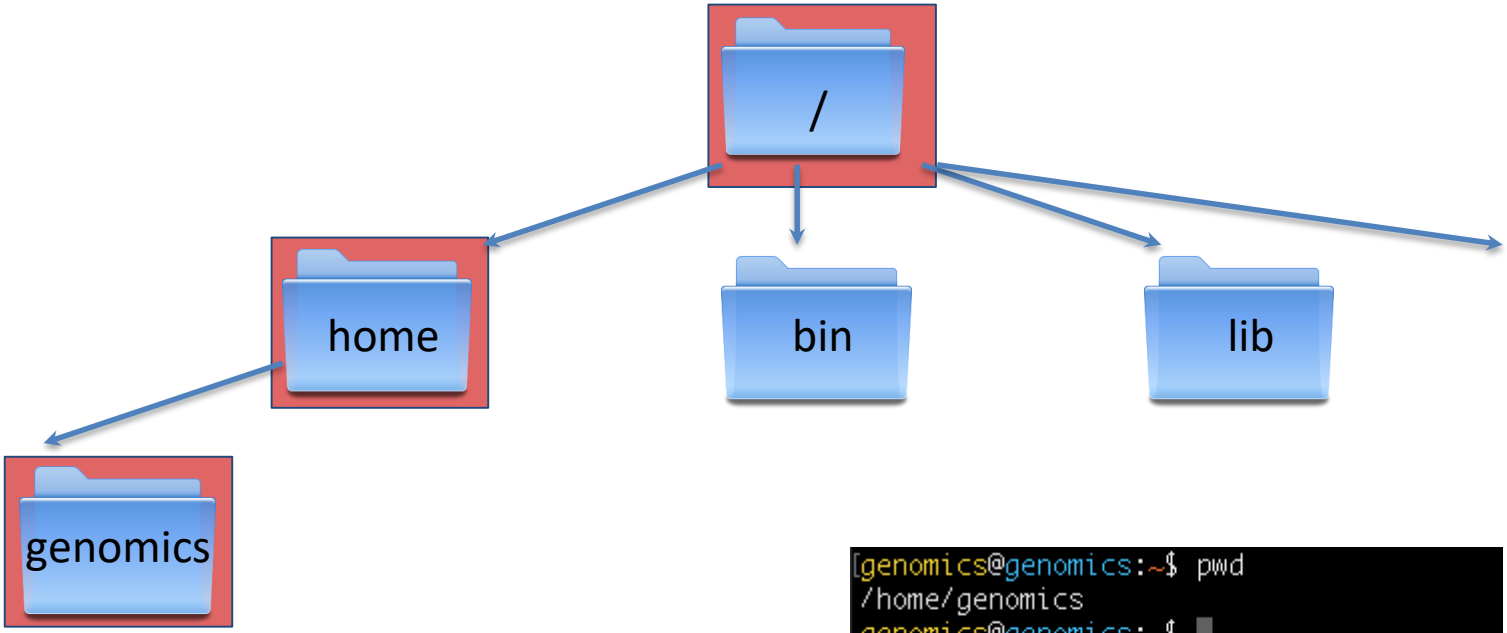
home

bin

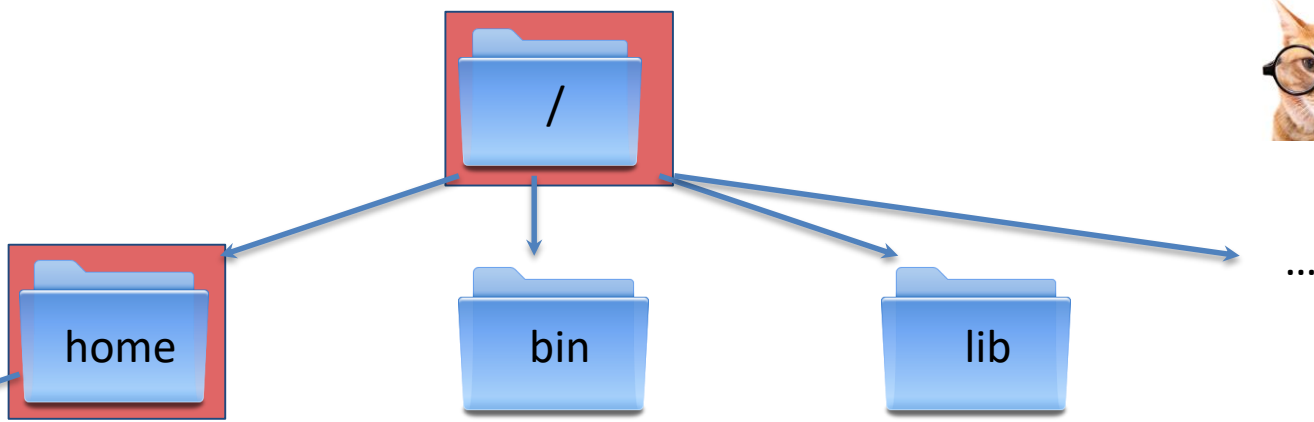
lib

...

genomics




```
genomics@genomics:~$ pwd
/home/genomics
genomics@genomics:~$
```



~

```
genomics@genomics:~$ pwd
/home/genomics
genomics@genomics:~$
```

This location is also known as your Home Directory

Tilde is shorthand for Home ~

Now let's create some directories and files

Make a directory

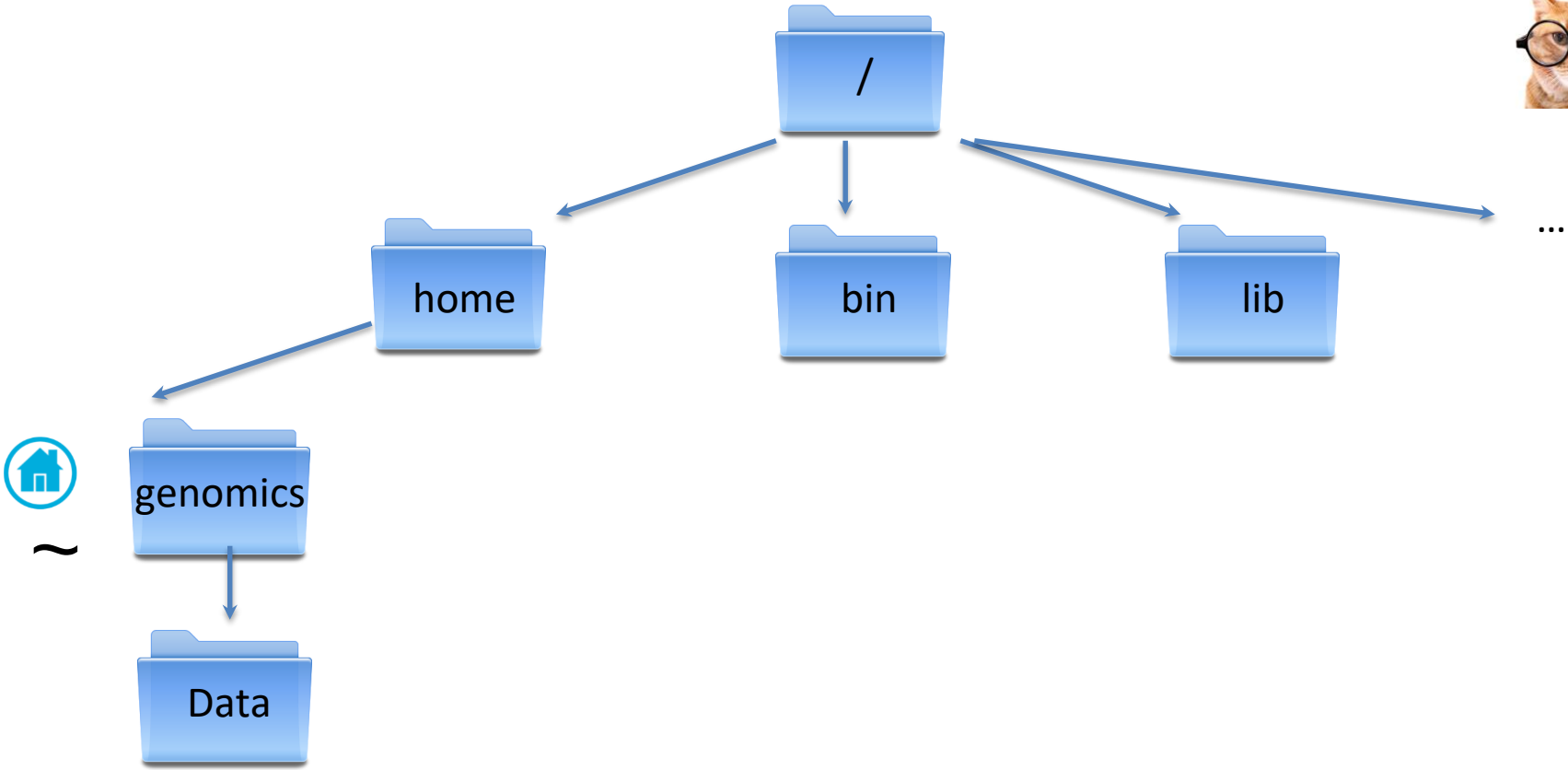
```
$ mkdir Data
```

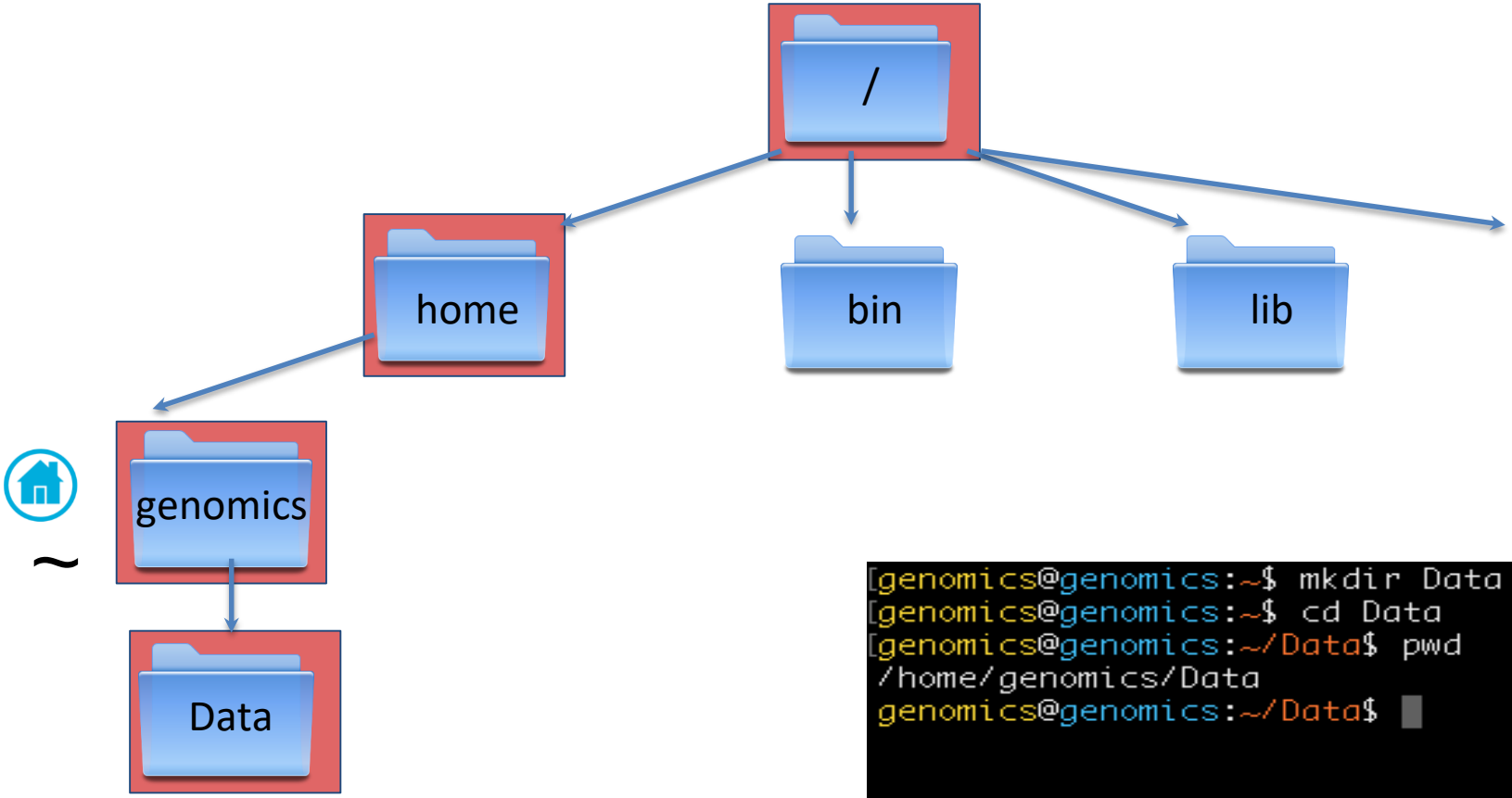
Change into this directory

```
$ cd Data
```

Now what is your present working directory?

NOTE! Directory names (and file names for the matter) can not contain spaces. Underscores are often used instead if you want to separate words.


/
home
bin
lib
...
genomics
~
Data




```
genomics@genomics:~$ mkdir Data
genomics@genomics:~$ cd Data
genomics@genomics:~/Data$ pwd
/home/genomics/Data
genomics@genomics:~/Data$
```

Now let's create some directories and files

Make an empty file

```
$ touch rags
```

And another two

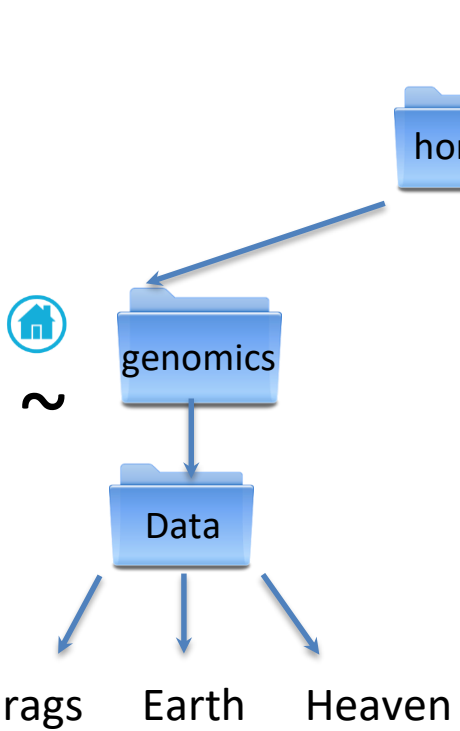
```
$ touch Earth
```

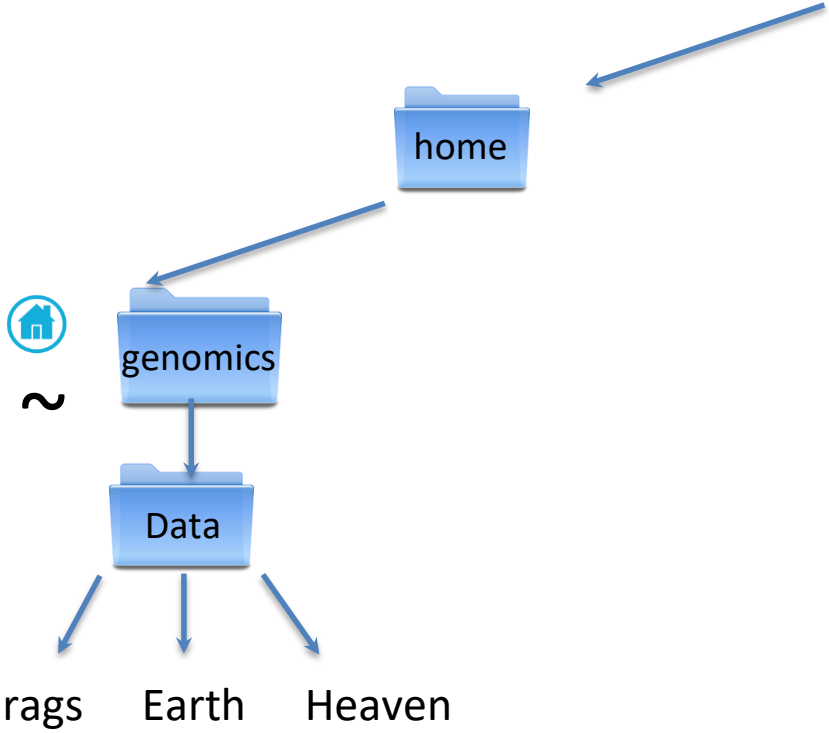
```
$ touch Heaven
```

Now let's list the contents of the current directory (Data)

```
$ ls
```

```
genomics@genomics:~/Data$ touch rags
genomics@genomics:~/Data$ touch Earth Heaven
genomics@genomics:~/Data$ ls
Earth  Heaven  rags
genomics@genomics:~/Data$
```

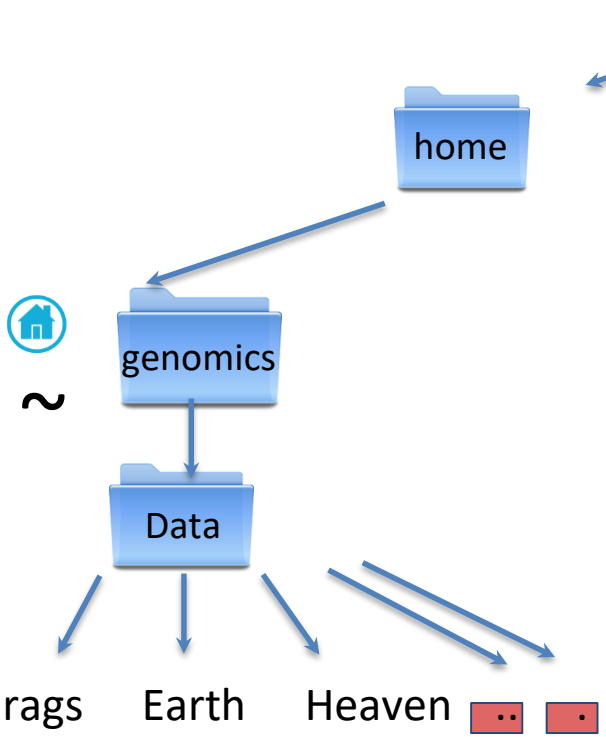

home
~
genomics
Data
rags
Earth
Heaven



Now list ALL of the files

```
$ ls -a
```

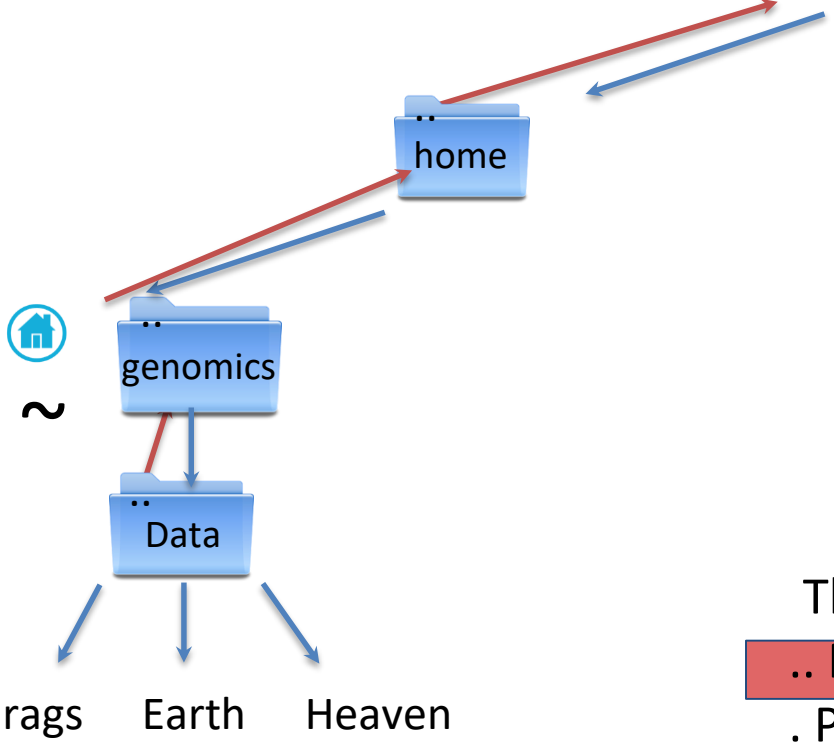
```
genomics@genomics:~/Data$ ls -a
.  ..  Earth  Heaven  rags
genomics@genomics:~/Data$
```



Now list ALL of the files

```
$ ls -a
```

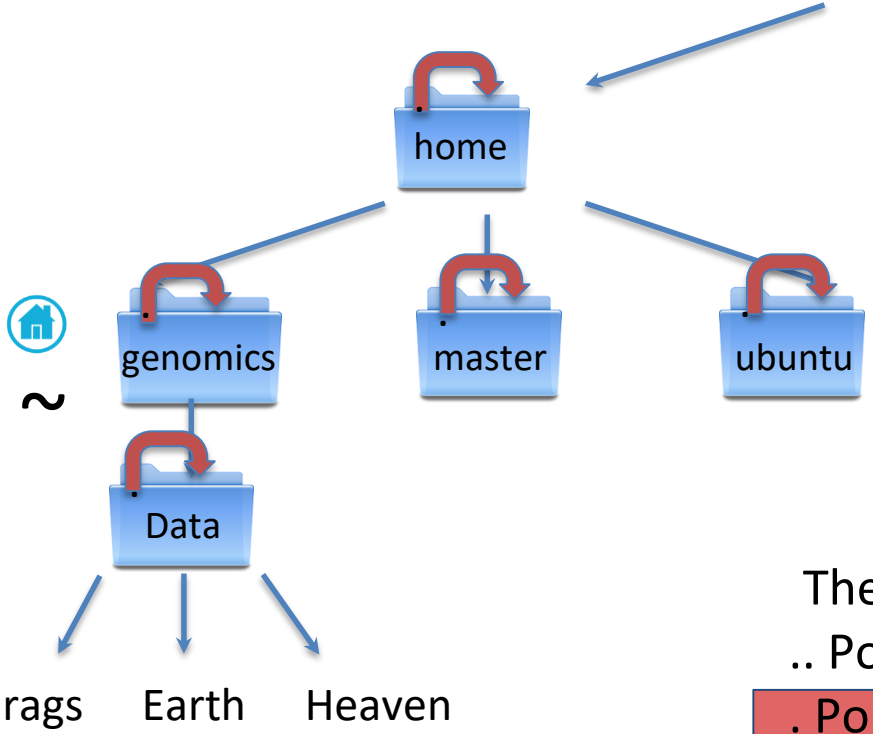
```
genomics@genomics:~/Data$ ls -a
.  ..  Earth  Heaven  rags
genomics@genomics:~/Data$
```



These special files are in every directory

.. Points to one directory above

. Points to the current directory



These special files are in every directory

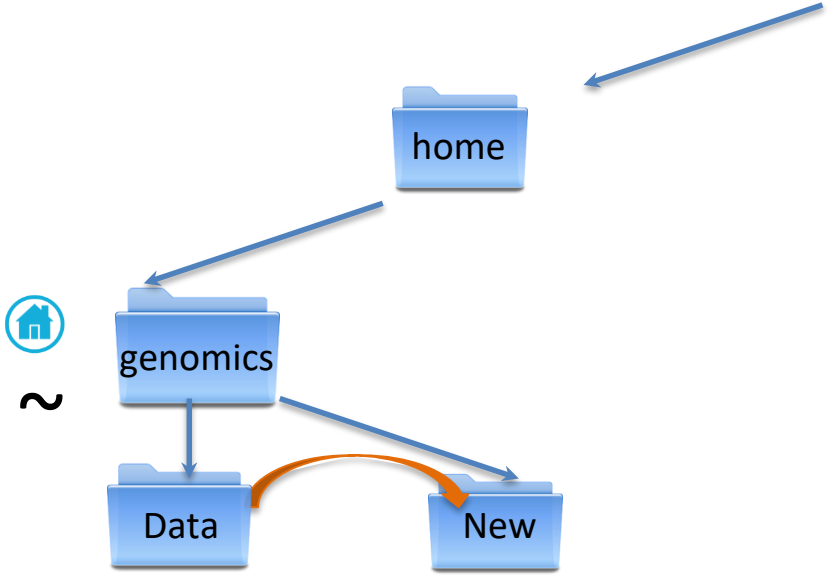
.. Points to one directory above

. Points to the current directory

. and .. are used for specifying location

Whenever you do anything on Linux
(move around, move a file, rename a file etc…)
You have to tell the system where that thing is
using a path

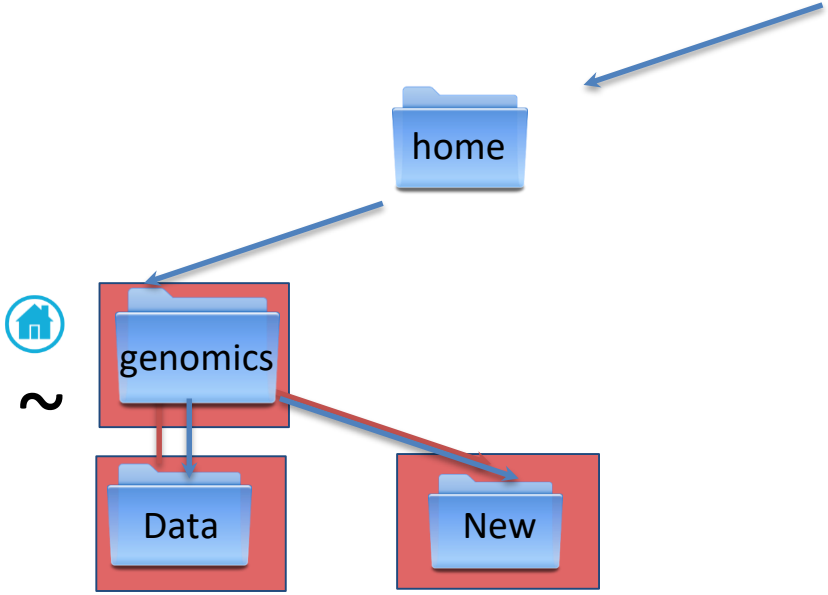
. and .. are part of RELATIVE paths



Moving from Data to New

RELATIVE PATH

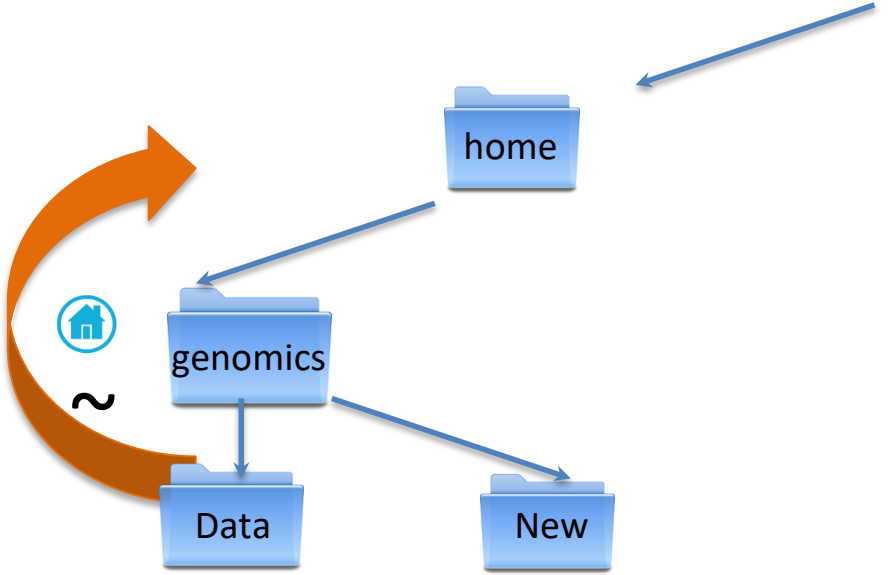
```
$ cd ../New
```



Moving from Data to New

RELATIVE PATH

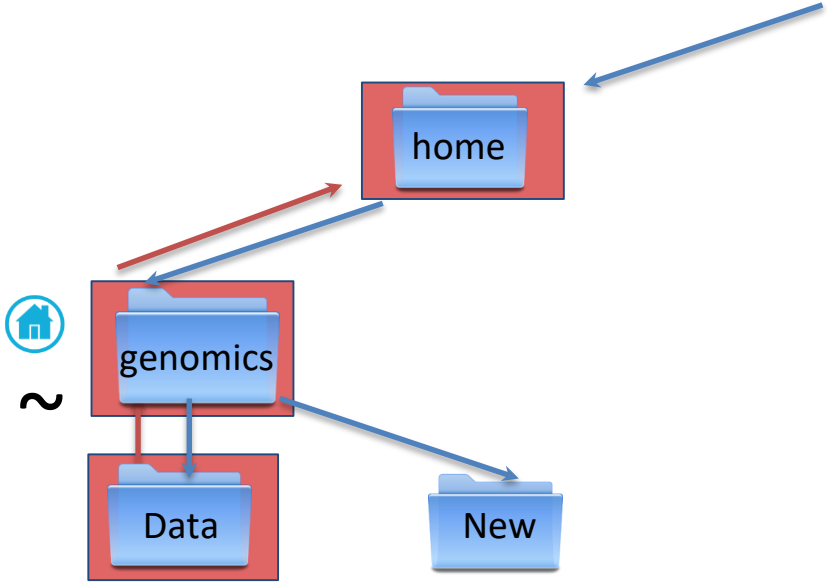
```
$ cd ../New
```



Moving from Data to home

RELATIVE PATH

```
$ cd ../../
```



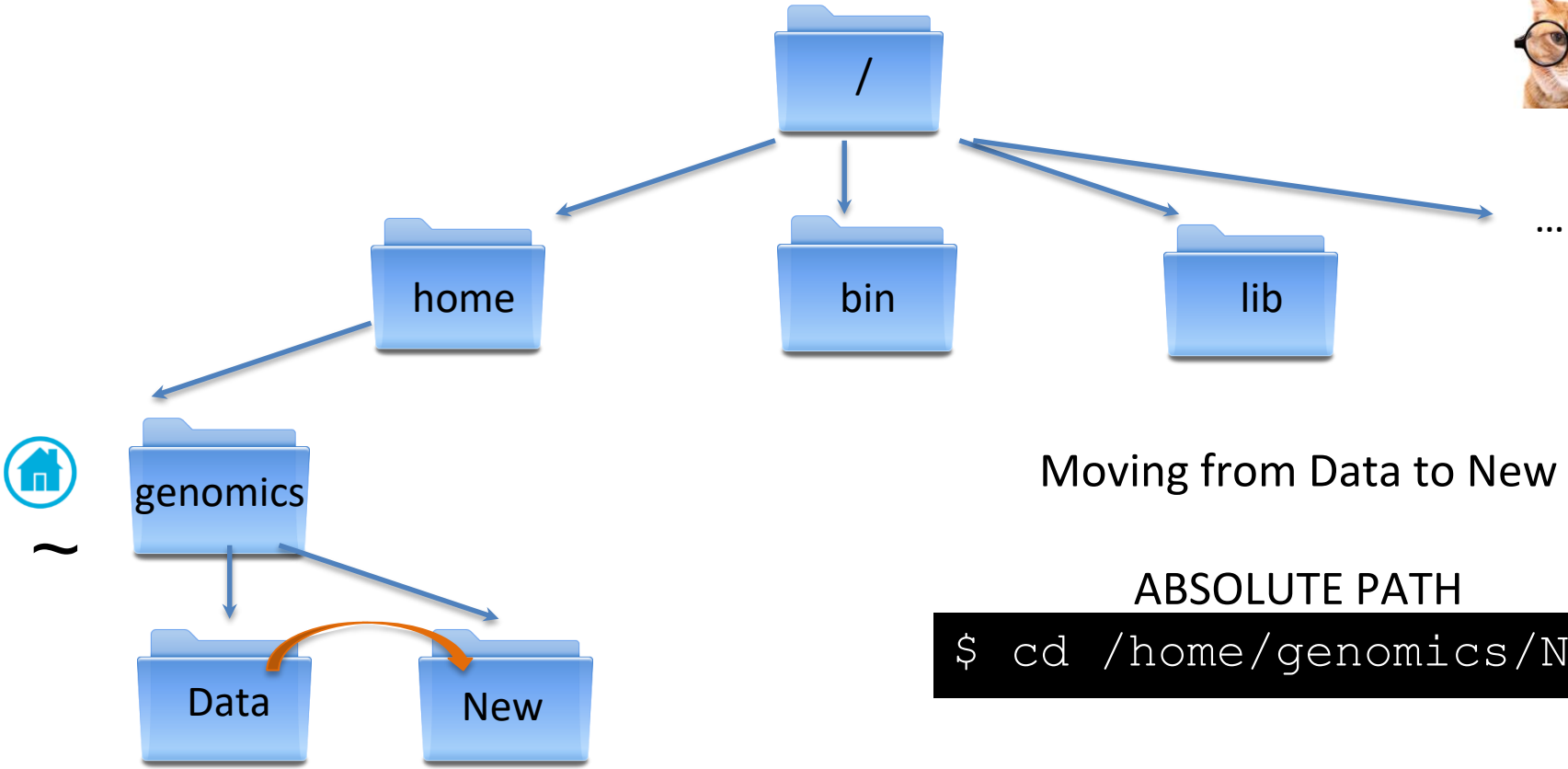
Moving from Data to home

RELATIVE PATH

```
$ cd ../../
```

Relative paths will always change depending on your location.

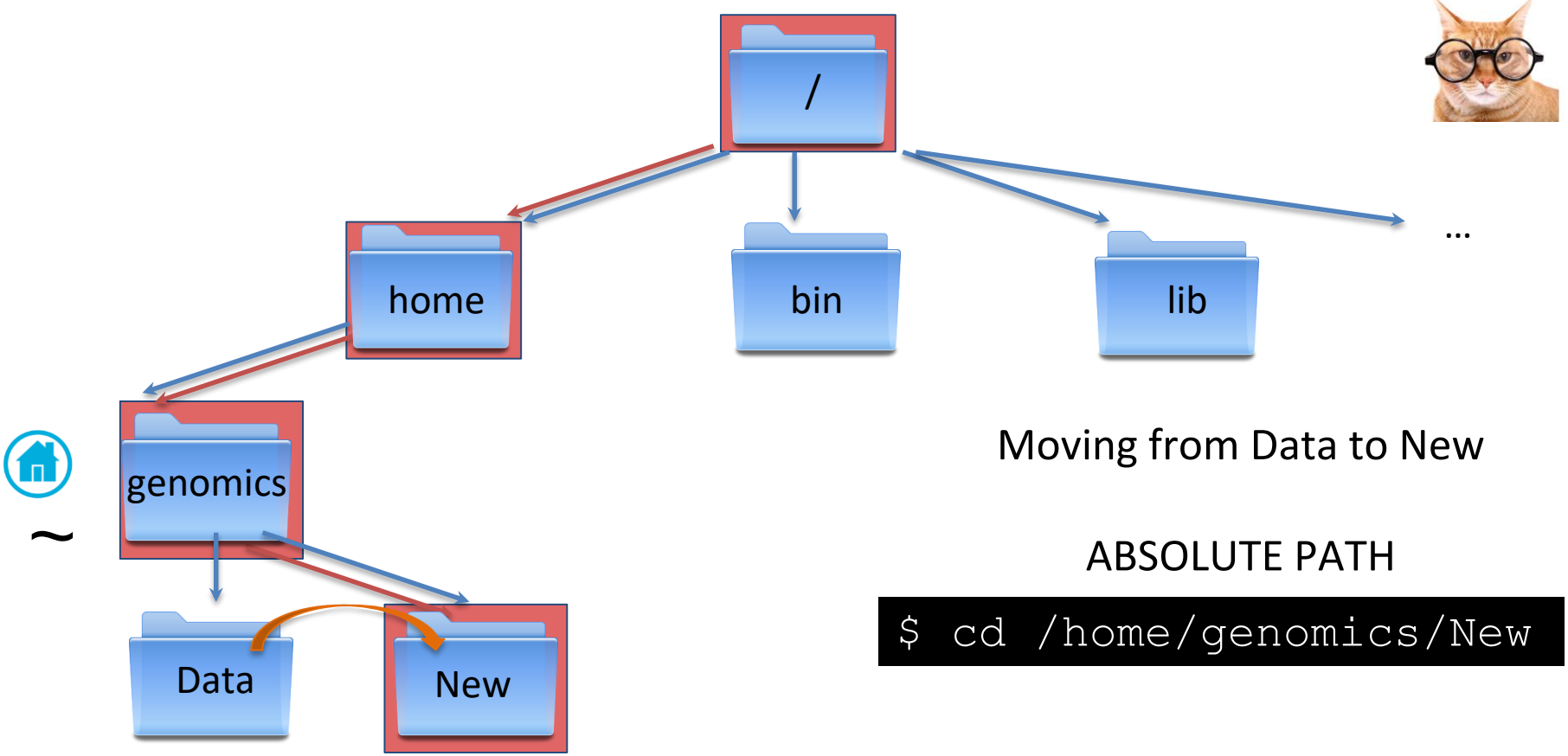
The alternative is ABSOLUTE paths.
These always start from root and will never change.



Moving from Data to New

ABSOLUTE PATH

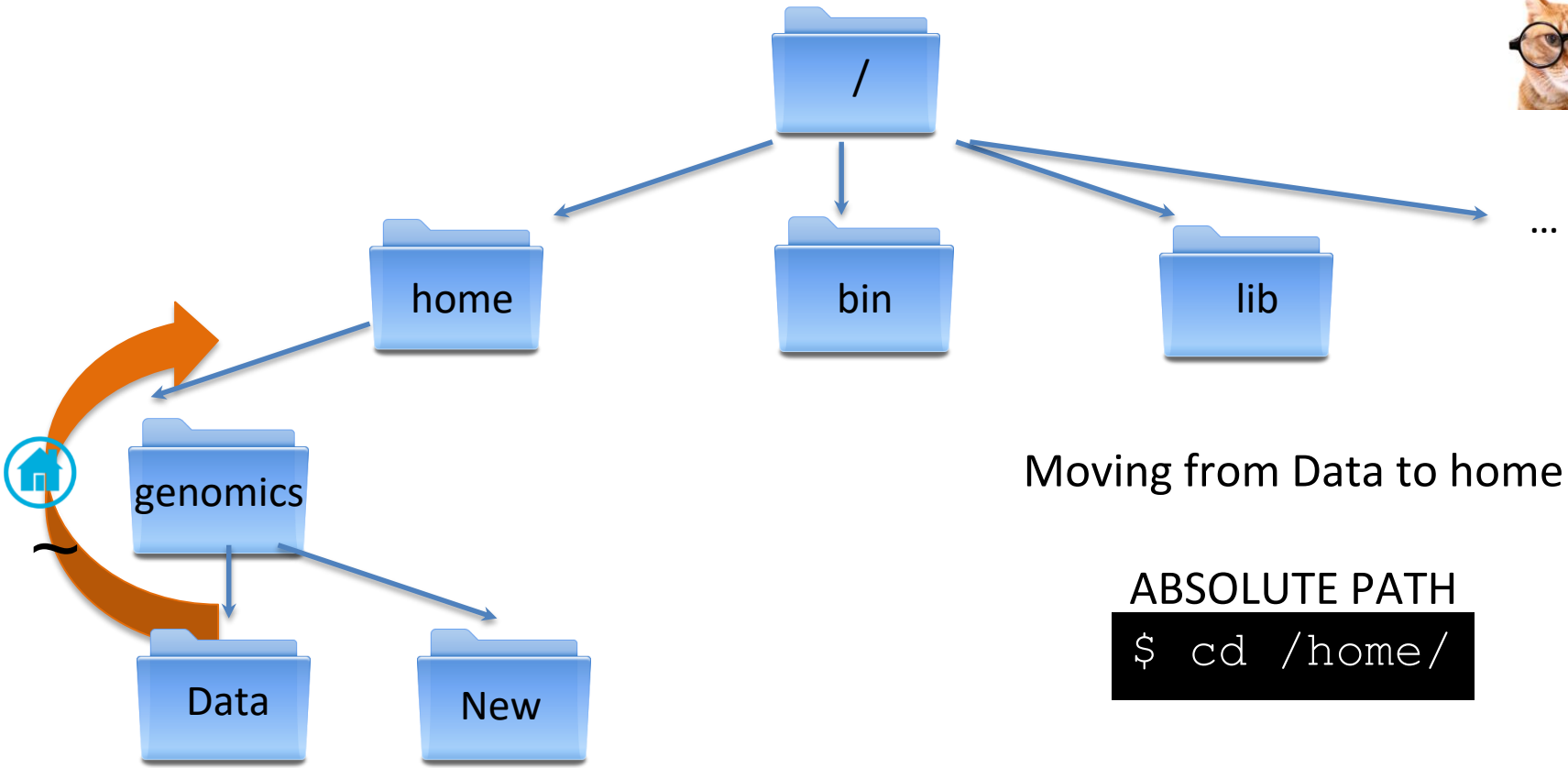
```
$ cd /home/genomics/New
```



Moving from Data to New

ABSOLUTE PATH

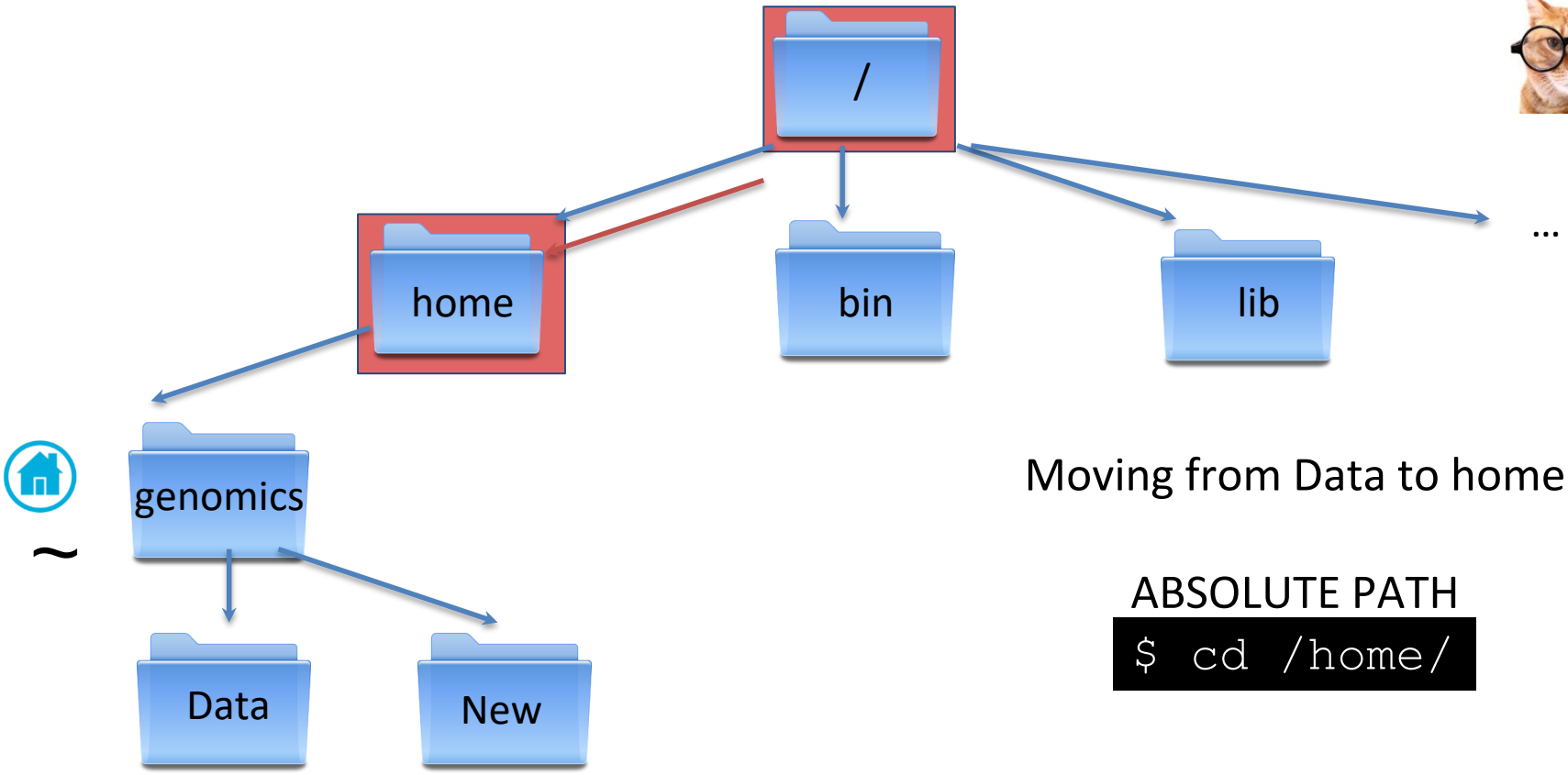
```
$ cd /home/genomics/New
```



Moving from Data to home

ABSOLUTE PATH

```
$ cd /home/
```



Moving from Data to home

ABSOLUTE PATH

```
$ cd /home/
```

Let's put this to practice

Where am I right now? (Should be the Data directory)

```
$ pwd
```

Change to the directory above

```
$ cd ../
```

Let's list the contents of the Data directory

```
$ ls ./Data/
```

CHALLENGE 1!

1. Move into the Data directory and list the contents of your home directory
2. In Data, make a new directory and move into this location
3. From this new directory, move into your own home directory (genomics) IN ONE COMMAND and check your location

Challenge 1!

1. Move into the Data directory and list the contents of your Home directory

```
$ cd Data
$ ls ..
```

OR `$ ls /home/genomics/` OR `$ ls ~`

2. In Data, make a new directory and move into this location

```
$ mkdir new
$ cd new
```

3. From this new directory, move into your Home directory IN ONE COMMAND and check your location

```
$ cd ../..
$ pwd
```

OR `$ cd /home/genomics/` OR `$ cd ~` OR `$ cd`

Any Questions So Far?

Wait a little !

Every binary program has a manual

To view the manual page, type man followed by the name of the program

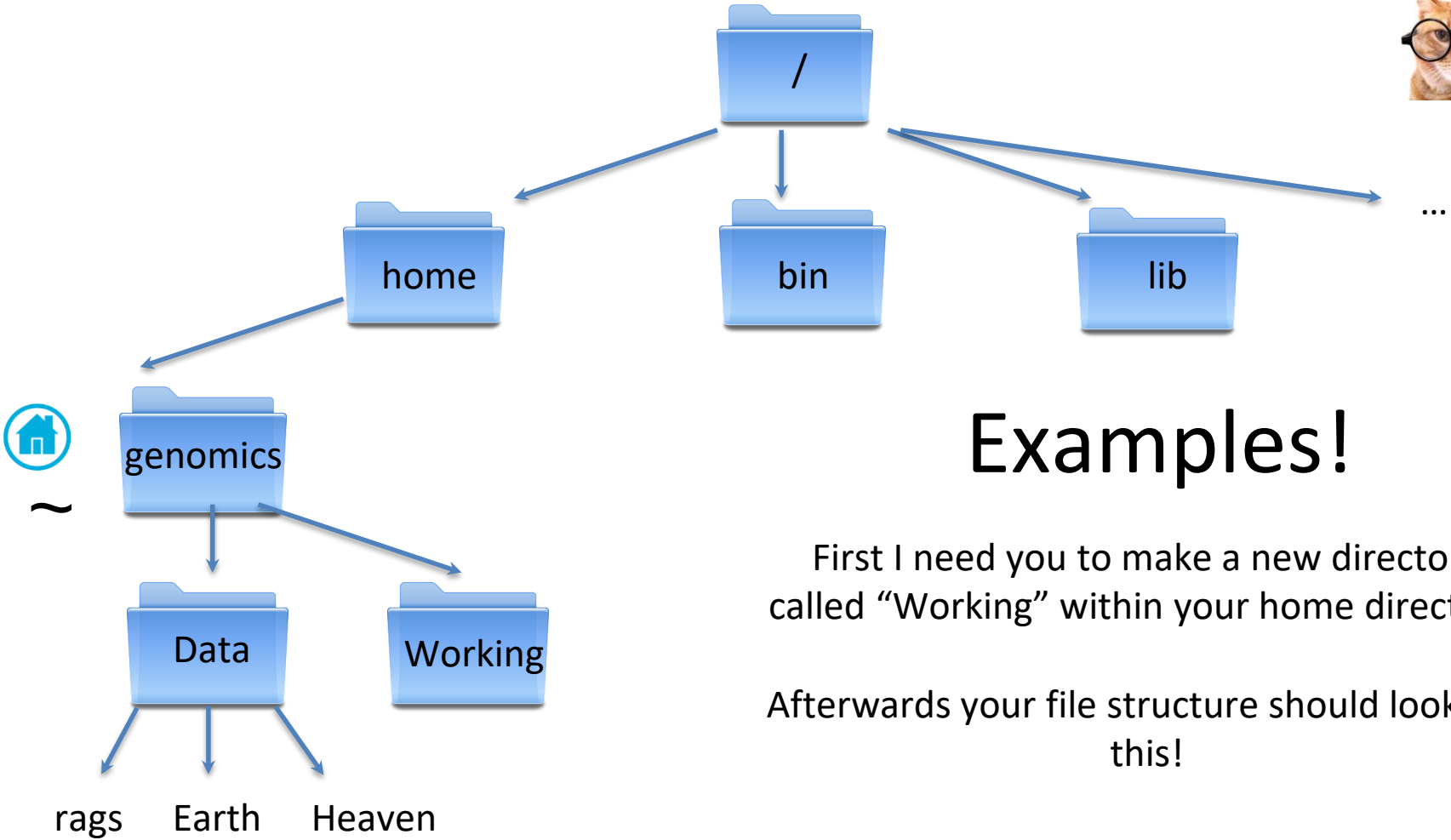
```
$ man <PROGRAMME>
```

Open the manual page for ls

```
$ man ls
```

Scroll through (enter) and find the options for:
long listing format (-l), human-readable sizes (-h) and sort by modification time (-t)

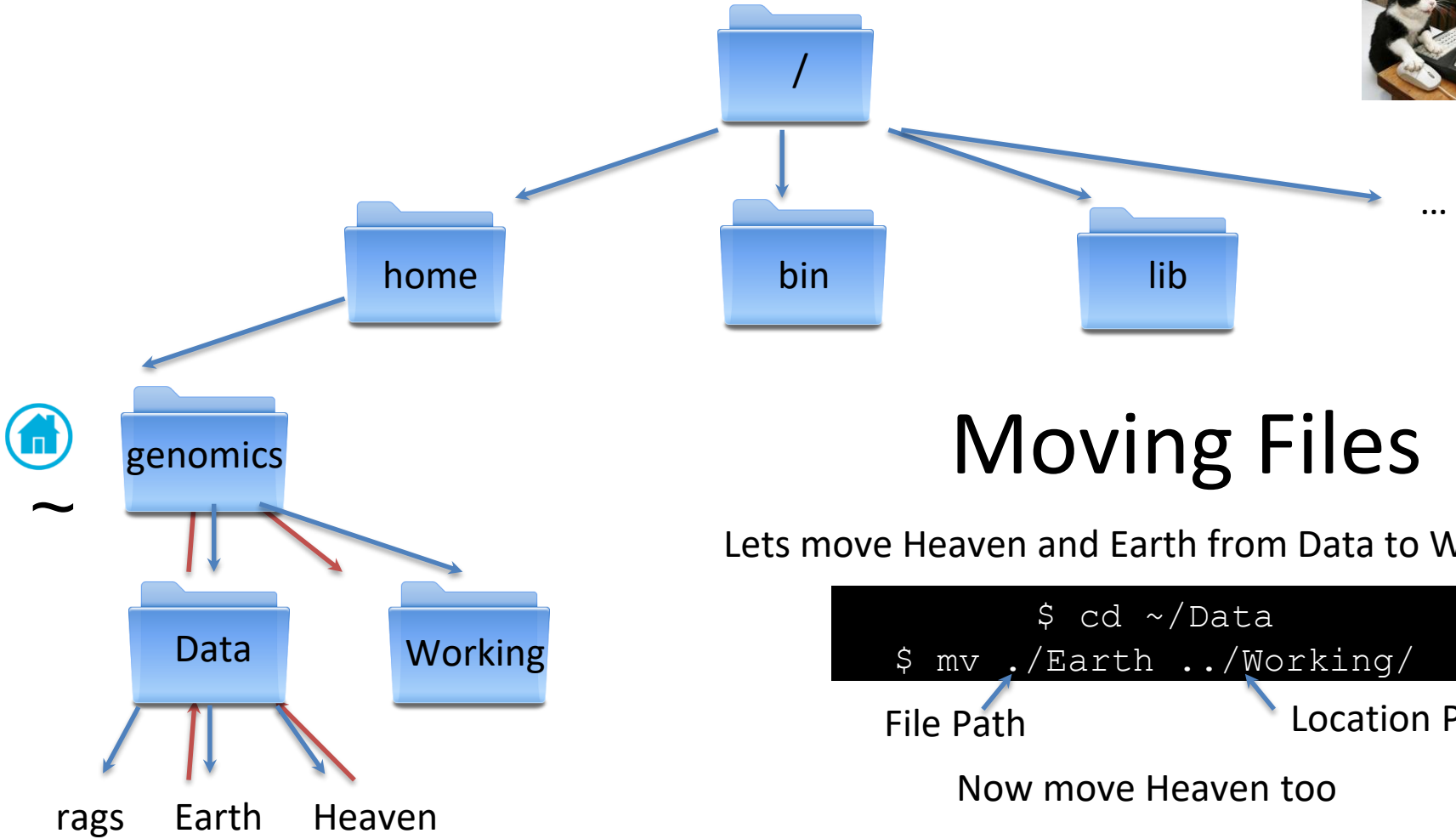
Exit the manual page (type q)



Examples!

First I need you to make a new directory called “Working” within your home directory.

Afterwards your file structure should look like this!



Moving Files

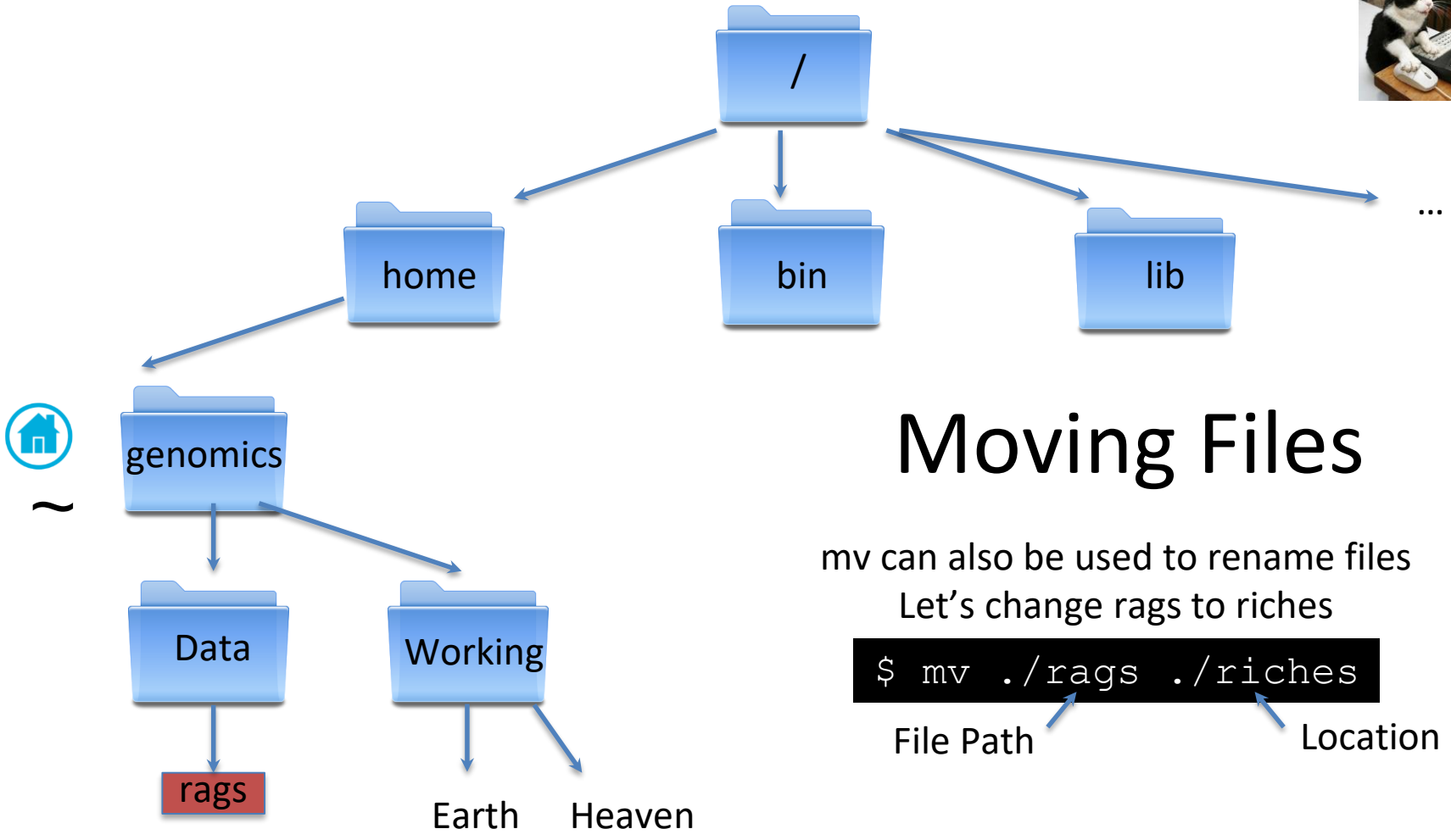
Lets move Heaven and Earth from Data to Working

```
$ cd ~/Data
$ mv ./Earth ../Working/
```

File Path

Location Path

Now move Heaven too



Moving Files

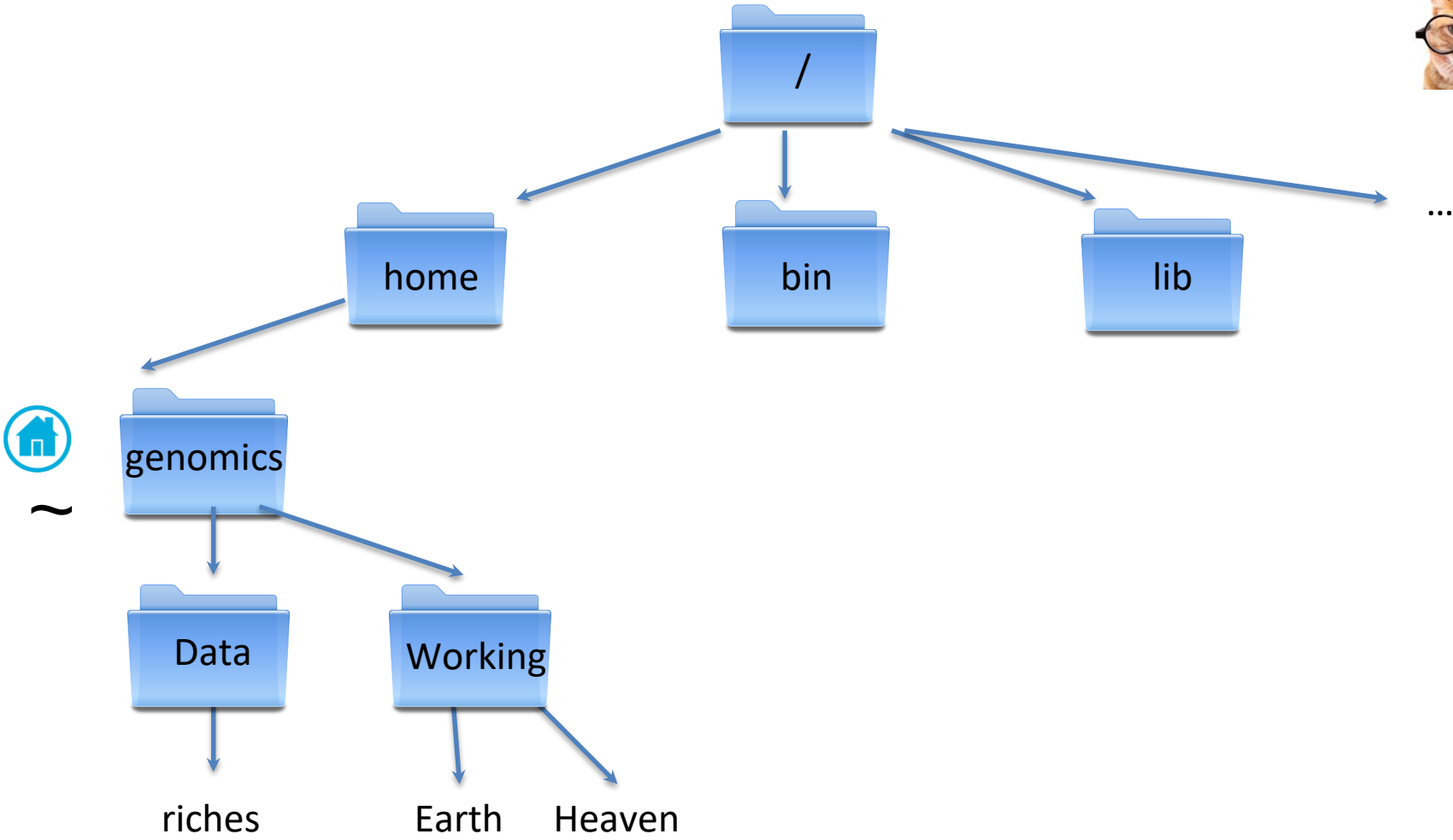
mv can also be used to rename files

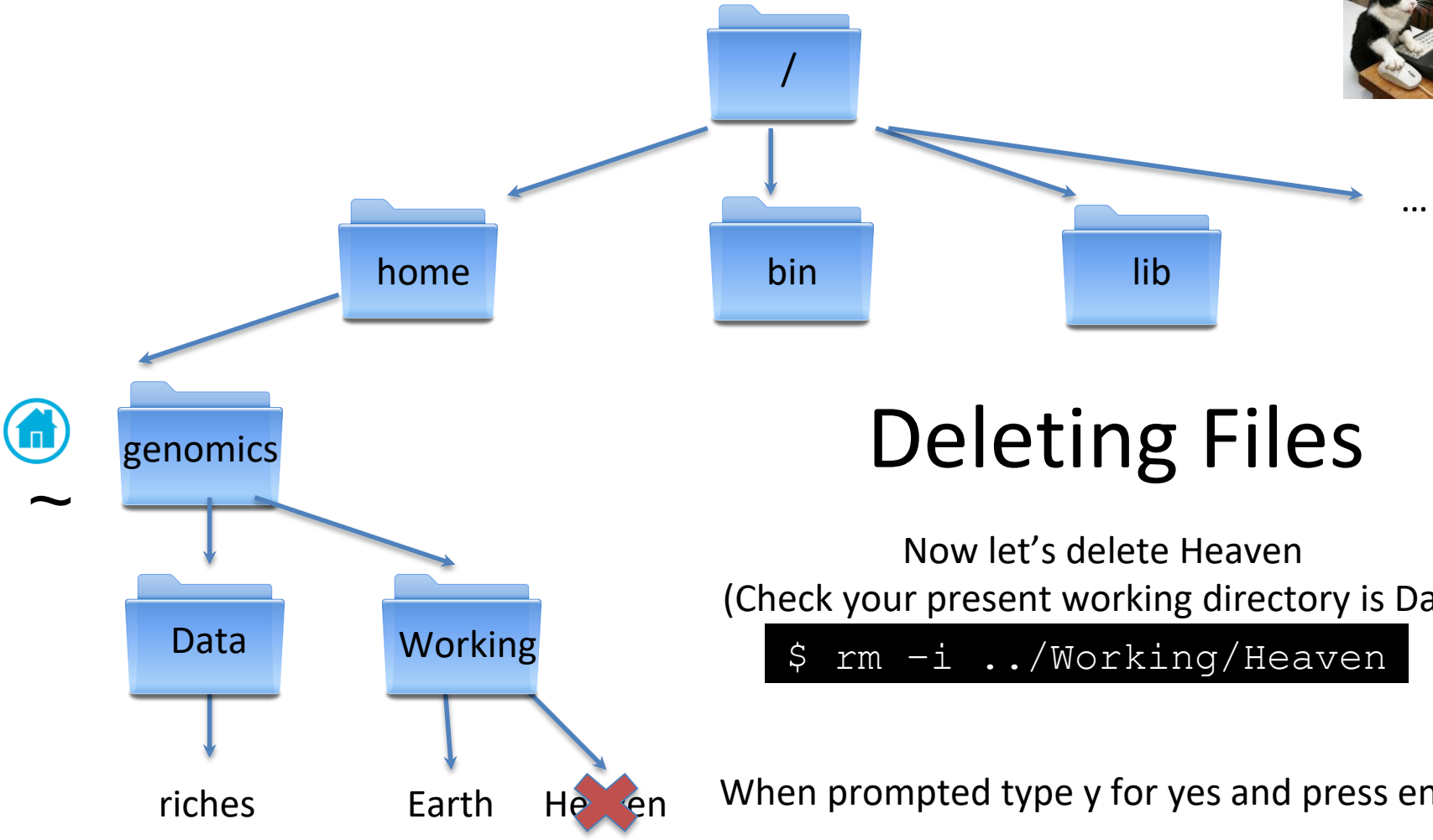
Let's change rags to riches

```
$ mv ./rags ./riches
```

File Path

Location Path


/
home
bin
lib
...
genomics
~
Data
Working
riches
Earth
Heaven

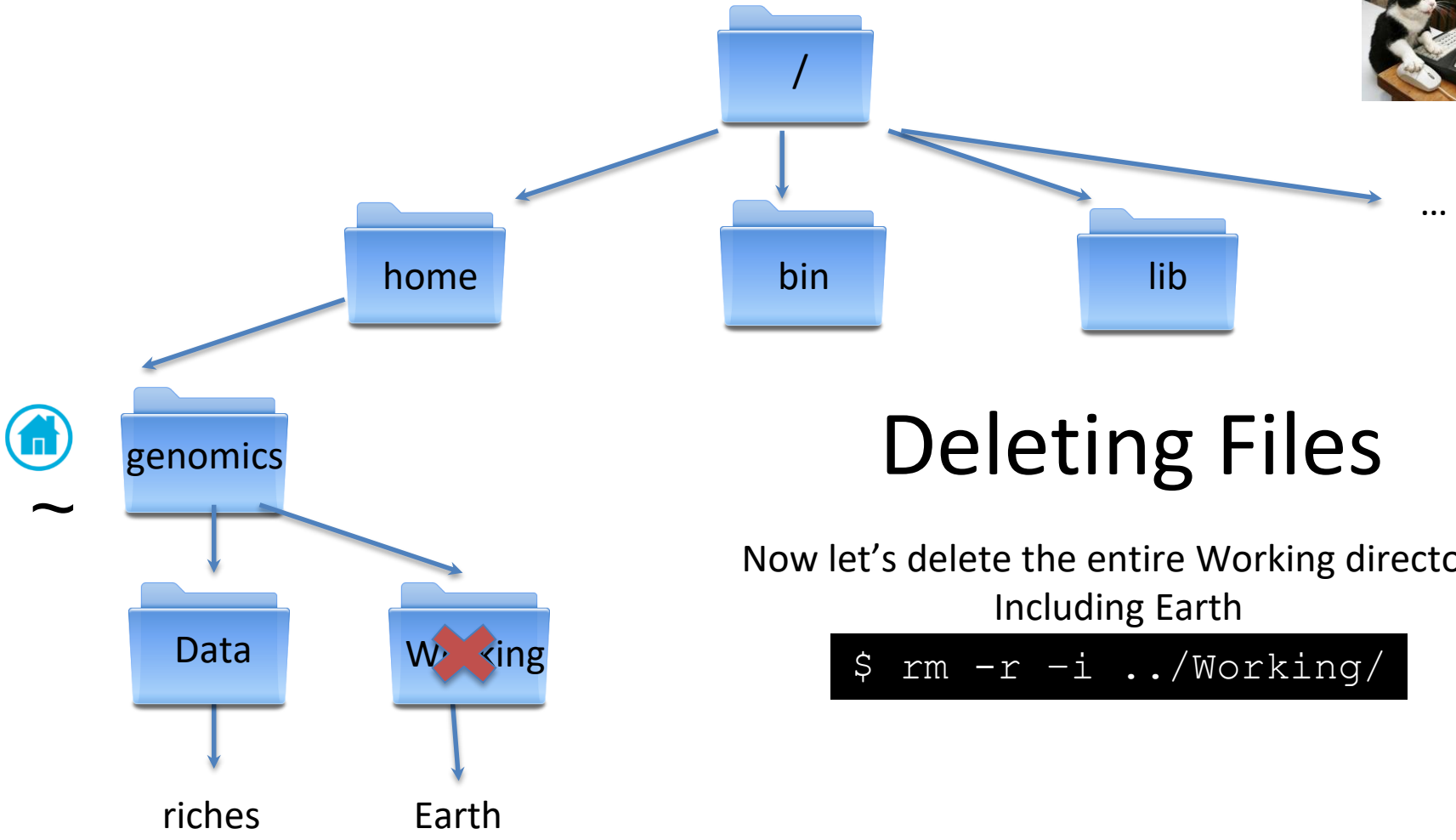


Deleting Files

Now let's delete Heaven
(Check your present working directory is Data)

```
$ rm -i ../Working/Heaven
```

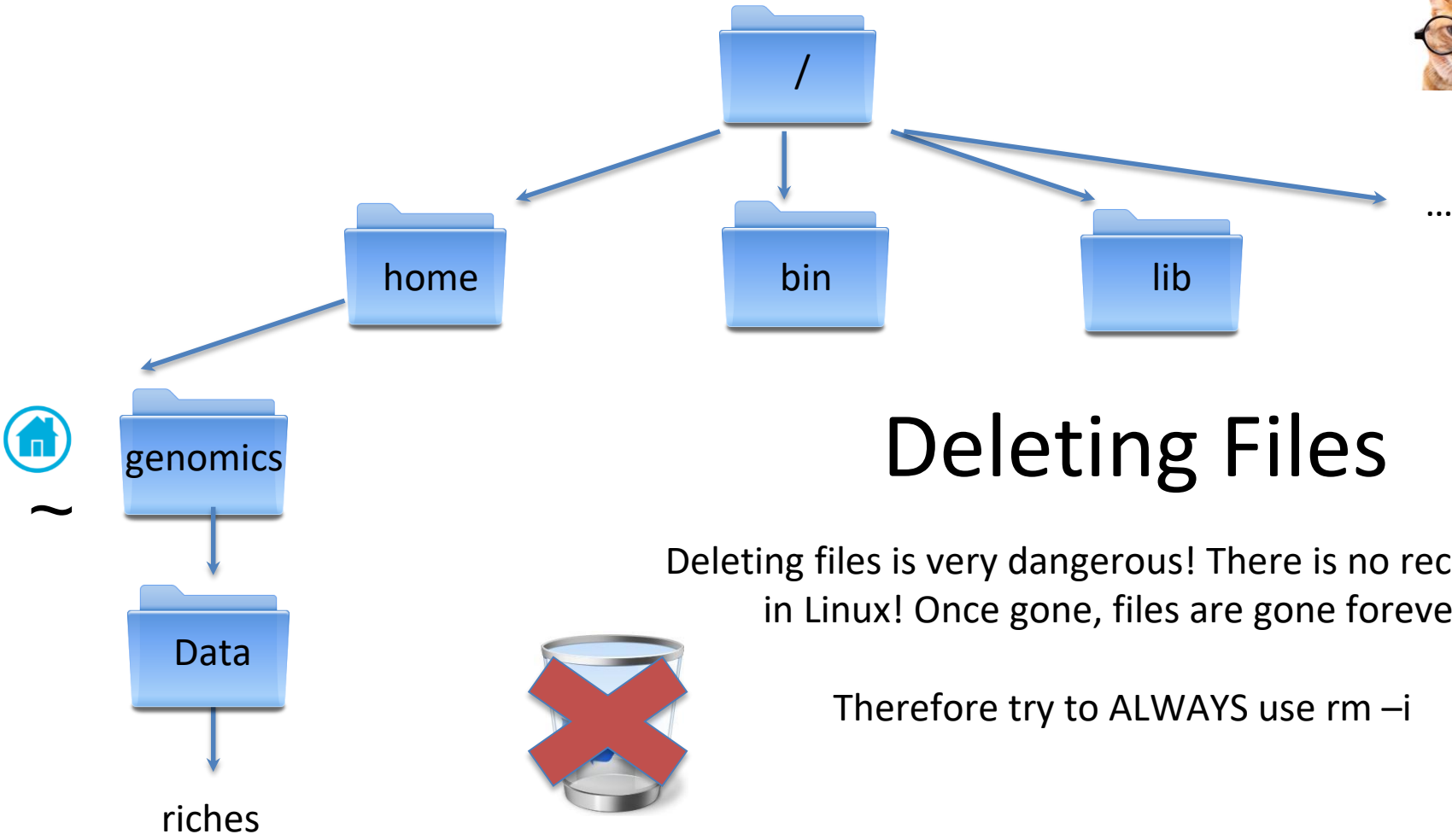
When prompted type y for yes and press enter



Deleting Files

Now let's delete the entire Working directory
Including Earth

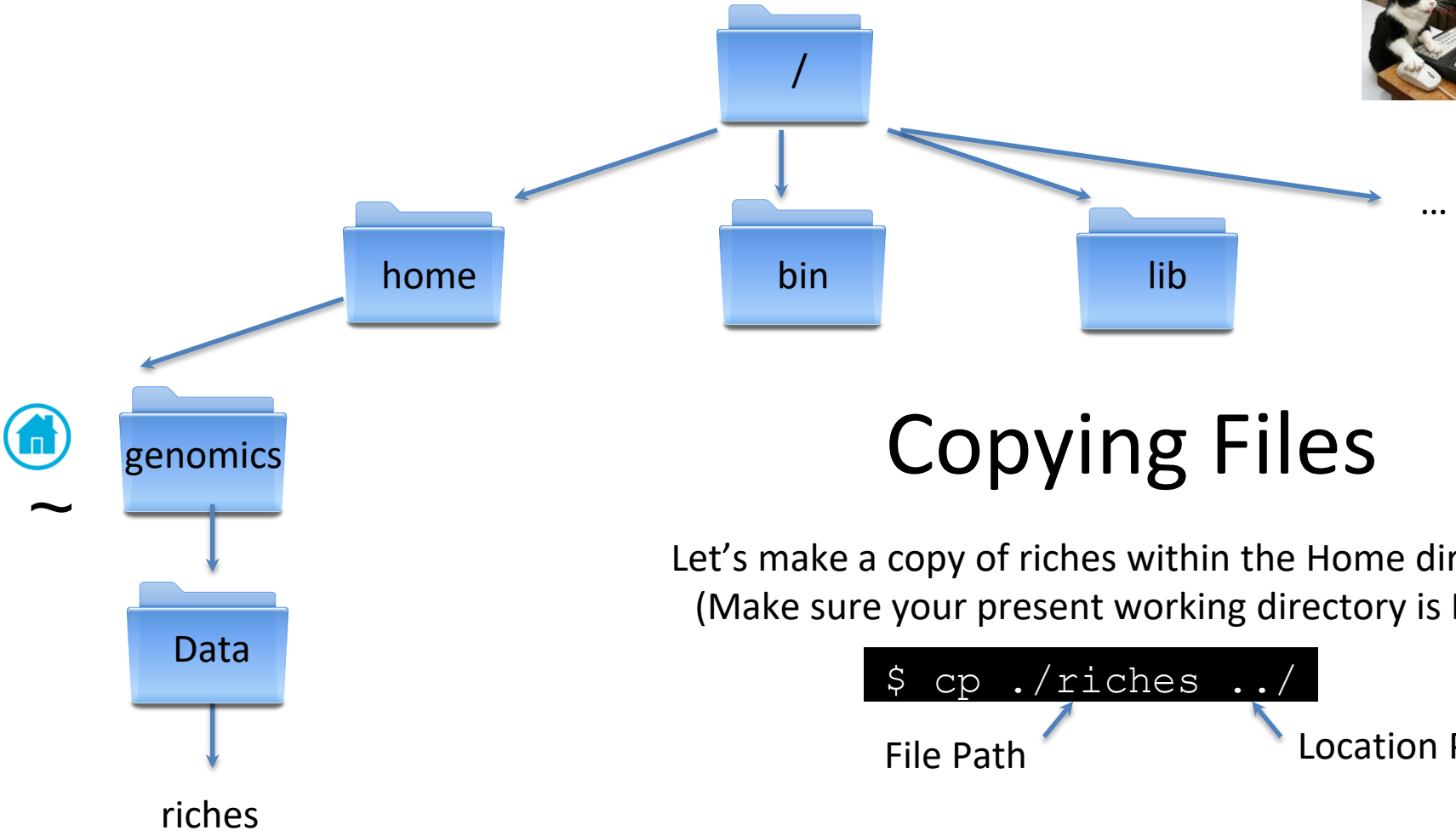
```
$ rm -r -i ../Working/
```



Deleting Files

Deleting files is very dangerous! There is no recycle bin in Linux! Once gone, files are gone forever!

Therefore try to ALWAYS use rm –i



Copying Files

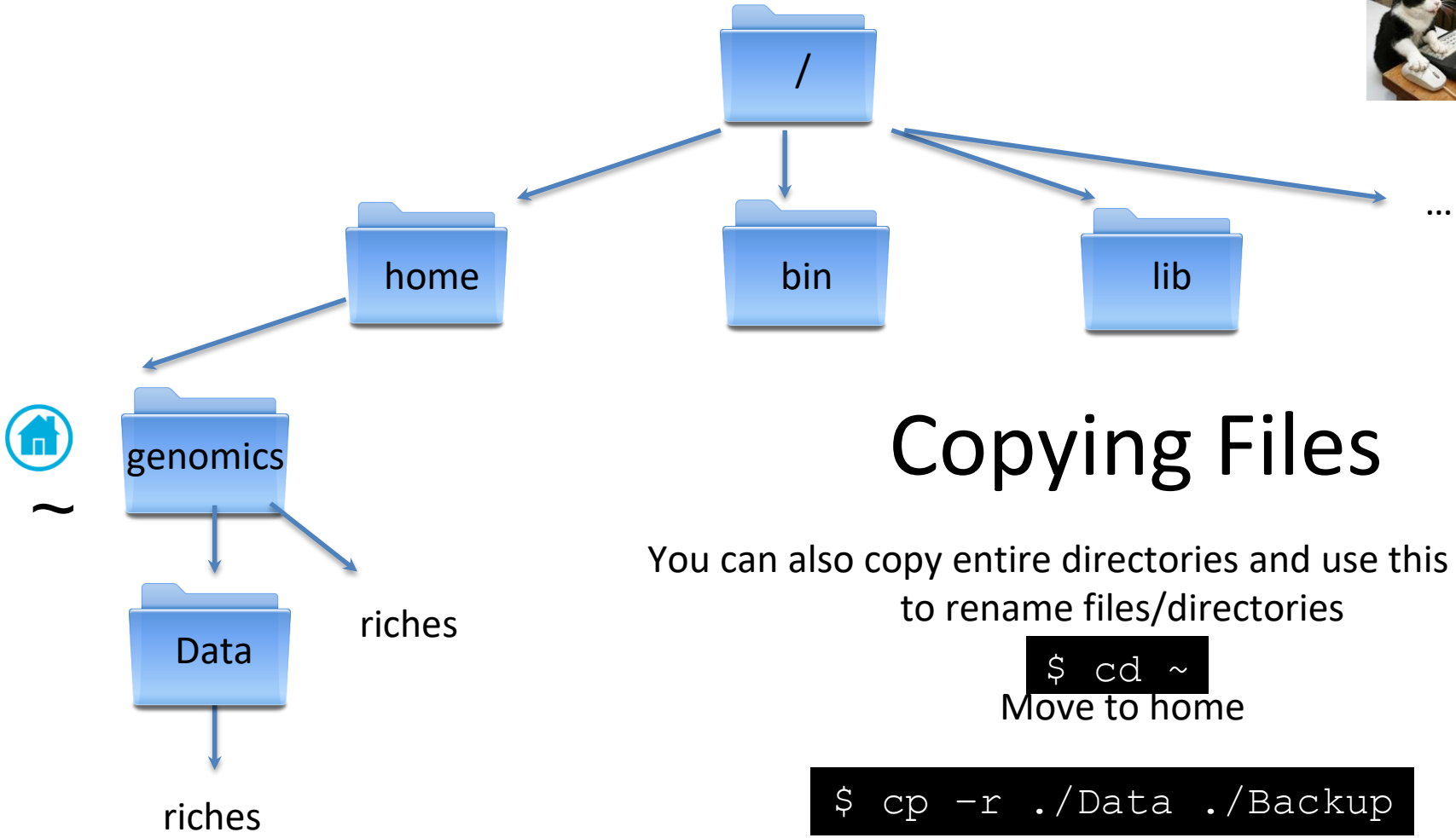
Let's make a copy of riches within the Home directory
(Make sure your present working directory is Data)

```
$ cp ./riches ../
```

File Path

Location Path

/
home
bin
lib
...
genomics
~
Data
riches
riches



Copying Files

You can also copy entire directories and use this function to rename files/directories

```
$ cd ~
```

Move to home

```
$ cp -r ./Data ./Backup
```

Make a copy of the Data directory here and call it Backup

/

home

bin

lib

...

~

genomics

Data

Backup

riches

riches

riches

Any Questions So Far?

The End of the second session

File Commands

ls – directory listing
ls -al – formatted listing with hidden files
cd *dir* - change directory to *dir*
cd – change to home
pwd – show current directory
mkdir *dir* – create a directory *dir*
rm *file* – delete *file*
rm -r *dir* – delete directory *dir*
rm -f *file* – force remove *file*
rm -rf *dir* – force remove directory *dir* *
cp *file1 file2* – copy *file1* to *file2*
cp -r *dir1 dir2* – copy *dir1* to *dir2*; create *dir2* if it doesn't exist
mv *file1 file2* – rename or move *file1* to *file2*
if *file2* is an existing directory, moves *file1* into directory *file2*
ln -s *file link* – create symbolic link *link* to *file*
touch *file* – create or update *file*
cat > *file* – places standard input into *file*
more *file* – output the contents of *file*
head *file* – output the first 10 lines of *file*
tail *file* – output the last 10 lines of *file*
tail -f *file* – output the contents of *file* as it grows, starting with the last 10 lines

Terminal Commands

- Run (VM or https://www.terminaltemple.com/)
  - Exploring your current directory
  - Making and changing directories
  - Removing files and directories
- Run (VM or https://sandbox.bio/tutorials/terminal-basics)
  - Viewing and manipulating files
  - Searching files
  - Putting it all together

Text Editors

These are pieces of software which can be used to edit files.
Think of them as Unix versions of Notepad.

Some have an interactive user interface – E.G. gedit

Some work from within the command line – E.G. nano, vim, emacs

Key Nano Commands

Ctrl + O – This saves the file. You will be asked for a file name. Type the name and press enter.

Ctrl + X – This exits nano. If the file is unsaved, you will be asked at this point if you'd like to save it.

How Do You Install Software?

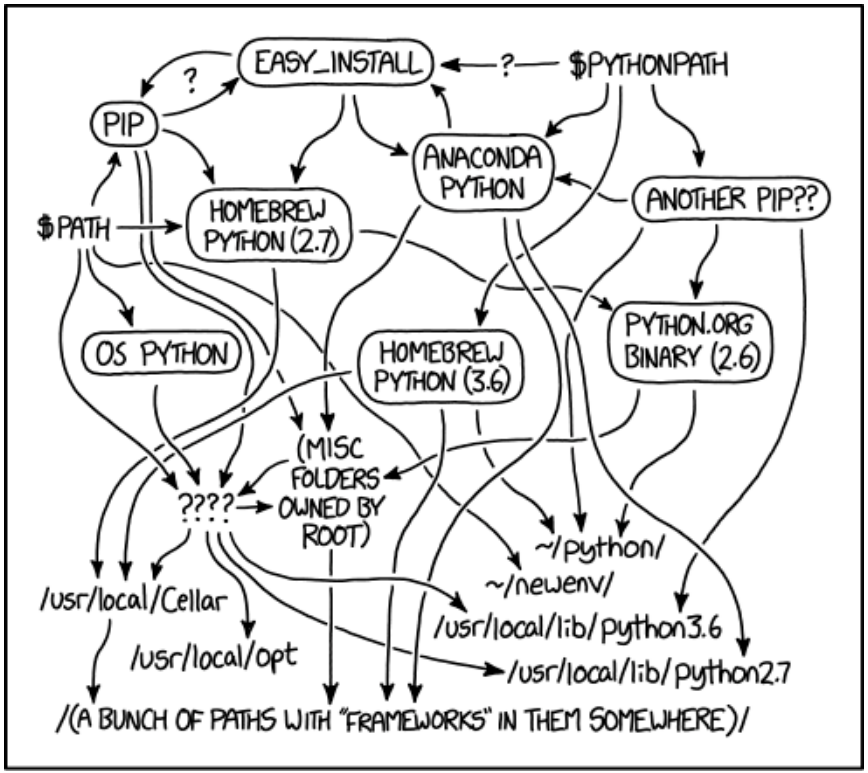
Some binary programs come with Ubuntu e.g. mkdir, ls etc…

However most software for bioinformatics needs to be installed.

when you begin working on a system you may need to do this.

If you’re using a shared compute resource, you’ll likely need to ask your system administrator to do this.

IT IS NOT AS EASY AS IT SOUNDS



https://xkcd.com/1987/

Software Installation

The “get and compile” method!

Get the software from somewhere and then install it manually.

GitHub

GitHub is a fantastic repository containing a lot of bioinformatics software! It works using git so it’s easy to download.

Challenge 2!

I want you to download and compile the software unicycler.

Here is the github page - https://github.com/rrwick/Unicycler

Make sure you are in your home directory.

Follow the instructions under “Build and run without installation”.

Take a read/glance of all of the information under “Requirements” and “Installation” – I just want you to read here!

What Have We Just Done?

```
git clone https://github.com/rrwick/Unicycler.git
```

This has downloaded the software from github

```
cd Unicycler
```

This has changed the location to this new directory

```
make
```

This has COMPILED the software

But what happens if you type unicycler on the command line now?

```
genomics@genomics:~$ unicycler
unicycler: command not found
genomics@genomics:~$
```

Why!? Compiling ≠ Installing!

Installation

For software to be truly installed, it needs to be added to the directory /usr/bin or /usr/local/bin

And this requires admin privileges which you don't have!

However you can still run the newly compiled software directly by using the path:

However! It still won't work…

What! I hear you cry! Why!?

Requirements

- Linux or macOS
- Python 3.4 or later
- C++ compiler with C++14 support:
  - GCC 4.9.1 or later
  - Clang 3.5 or later
  - ICC also works (though I don't know the minimum required version number)
- setuptools (only required for installation of Unicycler)
- For short-read or hybrid assembly:
  - SPAdes v3.6.2 or later (`spades.py`)
- For long-read or hybrid assembly:
  - Racon (`racon`)
- For polishing
  - Pilon (`pilon1.xx.jar`)
  - Java (`java`)
  - Bowtie2 (`bowtie2-build` and `bowtie2`)
  - Samtools v1.0 or later (`samtools`)
- For rotating circular contigs:
  - BLAST+ (`makeblastdb` and `tblastn`)

Dependencies

A lot of software needs other software to work…
Which in turn needs other software..
Which also needs other software...

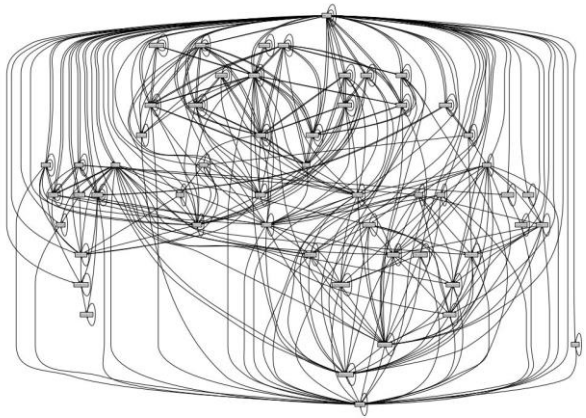


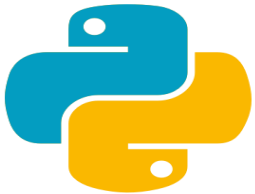
Figure 1.5.: The *dependency hell*: the runtime dependency graph of Mozilla Firefox

https://nixos.org/~eelco/pubs/phd-thesis.pdf

Software Managers

```
apt install
```

Synaptic



```
pip install
```

Important Initial Commands

1. sudo apt update
2. sudo apt install synaptic
3. sudo apt install pip

Confused!?
Don’t worry, you
aren’t the only one!

This section is just to make you aware of software installation techniques so you aren’t surprised when you get home and can’t find SAMtools on your system!